The elephant in the room is really a cow: using consumption corridors to define sustainable meat consumption in the European Union

Miriam Cué Rio, Bernice Bovenkerk, Jean-Christophe Castella, Daniel Fischer, Richard Fuchs, Minna Kanerva, Mark D A Rounsevell, Nicolas Salliou, Eric Olivier Verger, Elin Röös

▶ **To cite this version:**

Miriam Cué Rio, Bernice Bovenkerk, Jean-Christophe Castella, Daniel Fischer, Richard Fuchs, et al.. The elephant in the room is really a cow: using consumption corridors to define sustainable meat consumption in the European Union. Sustainability Science, 2022, 17 (online first), pp.1-19. 10.1007/s11625-022-01235-7 . hal-03832854

HAL Id: hal-03832854
https://hal.inrae.fr/hal-03832854

Submitted on 28 Oct 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Distributed under a Creative Commons Attribution 4.0 International License

Sustainability Science
https://doi.org/10.1007/s11625-022-01235-7

SPECIAL FEATURE: ORIGINAL ARTICLE

Dietary Transitions and Sustainability: Current Patterns and Future Trajectories

The elephant in the room is really a cow: using consumption corridors to define sustainable meat consumption in the European Union

Miriam Cué Rio[1] · Bernice Bovenkerk[2] · Jean-Christophe Castella[1] · Daniel Fischer[3] · Richard Fuchs[4] · Minna Kanerva[5] · Mark D. A. Rounsevell[4,6,7] · Nicolas Salliou[8] · Eric O. Verger[9] · Elin Röös[10]

Received: 27 January 2022 / Accepted: 8 September 2022
© The Author(s) 2022

Abstract

Implementing the European Green Deal requires a consistent food systems' policy that involves not only targeting the supply side but also conducting extensive changes in diets at the consumer level. Reducing meat consumption is an obvious strategy to put the European food system on track to meet the Green Deal's goals. This cannot be achieved by focusing solely on consumer choice and individual responsibility. Stronger governance is required to reduce the scale of meat consumption to sustainable levels. Such governance needs to be informed by a holistic definition of "sustainable meat consumption", designed to ensure that important sustainability priorities are not neglected, and to account for all emissions associated with EU consumption, regardless of where production takes place. This article presents a conceptual framework to define "sustainable meat consumption" based on the concept of consumption corridors (CCs). A CC is the space between a minimum (the floor) and maximum (the ceiling) consumption level, which allows everybody to satisfy their needs without compromising others' ability to meet their own. Embedded in a powerful set of principles (recognizing universal needs; tackling both over and under-consumption; framing food as a common good; promoting public participation; and addressing environmental justice and planetary sustainability), CCs are attuned to the Green Deal's ambition to "leave no one behind", in the EU and beyond. CCs provide a demand-side solution encompassing a more equitable alternative to discuss what is actually a "fair share" of the world's limited resources when it comes to meat consumption.

Keywords Sustainable meat consumption · Consumption corridors · Demand-side solutions · European Green Deal · Conceptual framework · Food and environmental justice

Handled by Alexandros Gasparatos, University of Tokyo, Japan.

✉ Miriam Cué Rio
miriam.cue-rio@ird.fr

[1] SENS, IRD, CIRAD, Univ Paul Valery Montpellier 3, Univ Montpellier, UMR SENS, Site St Charles, Route de Mende, Cedex 5, 34199 Montpellier, France

[2] Wageningen University and Research, Philosophy Group, Wageningen University, Hollandseweg 1, 6706 KN Wageningen, The Netherlands

[3] Wageningen University and Research, Strategic Communication Group, Wageningen University, Hollandseweg 1, 6706 KN Wageningen, The Netherlands

[4] Land Use Change & Climate Research Group, IMK-IFU, Karlsruhe Institute of Technology (KIT), Kreuzeckbahnstraße 19, Garmisch-Partenkirchen, 82467 Karlsruhe, Germany

[5] artec, Sustainability Research Center, University of Bremen, Enrique-Smith-Str. 7, 28359 Bremen, Germany

[6] Institute of Geography & Geo-Ecology, Karlsruhe Institute of Technology, Karlsruhe, Germany

[7] School of GeoSciences, University of Edinburgh, Drummond Street, UK

[8] PLUS, IRL, Swiss Federal Institute of Technology in Zürich (ETH), Stefano- Franscini-Platz 5, 8049 Zurich, Switzerland

[9] MoISA, Univ Montpellier, CIRAD, CIHEAM-IAMM, INRAE, Institut Agro, IRD, 911, avenue d'Agropolis, Cedex 5, 34394 Montpellier, France

[10] Department of Energy and Technology, Swedish University of Agricultural Sciences, Lennart Hjelms väg 9, 75007 Uppsala, Sweden

Published online: 27 October 2022

Introduction

The European Green Deal is a new growth strategy setting ambitious targets to transform the EU into a modern, resource-efficient and competitive economy. Proposed by the European Commission (EC) in response to the Paris Agreement's objective of limiting global warming to 1.5 °C above pre-industrial levels, it is intended to guide the overall EU response to climate and environmental challenges by making Europe the first climate-neutral continent (EC 2019). The core ambition is to achieve climate neutrality by 2050, marked by an intermediate step to reduce net greenhouse gas (GHG) emissions by at least 55% by 2030 compared to 1990. Both targets have become legally binding, following the adoption of the European Climate Law (EU 2021). Various Green Deal flagship initiatives have set specific targets impacting the agricultural sector. For example, the Farm-to-Fork Strategy (F2F) aims to halve nutrient losses, the use of chemical pesticides, and the sales of antimicrobials for farmed animals. It also seeks to improve animal welfare, and to implement organic farming on at least 25% of the EU's agricultural land (EC 2020a). The EU Biodiversity (EC 2020b) and Forest (EC 2021) Strategies focus on: (a) creating protected areas covering at least 30% of the land; (b) restoring high-diversity landscape features in at least 10% of agricultural areas; and (c) planting 3 billion trees.

Several studies, mainly using agro-economic models, have looked at the specific impact of selected Green Deal targets on agricultural output. They all point to declining agricultural production in the EU (Barreiro-Hurle et al. 2021; Beckman et al. 2020; Henning and Witzke 2021), mainly for livestock products (Henning and Witzke 2021). Meat prices are increasing, due to the combined effect of shrinking animal herds and a relatively inelastic food demand (Barreiro-Hurle et al. 2021). If the EU acts alone, a significant part of the gains in terms of emissions from reducing EU production could be leaked to other parts of the world, as declining production in the EU could be replaced by production in non-EU regions (Barreiro-Hurle et al. 2021). Henning and Witzke (2021) calculate that the F2F targets would cause a substantial increase in agricultural GHG emissions in non-EU countries, and a reduction of forest areas by approximately 5 million ha. The greatest leakage effects are expected to result from animal products, as the EU net export position for some of these products (especially beef) reverts to a net import position (Henning and Witzke 2021). These authors conclude that, under current circumstances, the F2F will not be effective against global climate change.

However, such studies tend to consider only a limited and uneven selection of targets, and thus fail to explain the overall impact of the totality of the Green Deal's strategies. In particular, their emphasis on the production side fails to capture a full food systems perspective including the effects of, for example, a reduction in food waste or changing diets (Barreiro-Hurle et al. 2021). Such studies (Barreiro-Hurle et al. 2021; Beckman et al. 2020; Henning and Witzke 2021) seem to mirror the Green Deal's policy, in which the strict targets on agricultural production contrast starkly with the few restrictions on food consumption. Their conclusions, however, suggest that targeting agricultural production will not be effective in reducing climate change unless demand is adjusted in line with reductions in production.

It is well established that animal-based foods tend to have far higher GHG emissions than plant-based alternatives, both in total and in per protein produced (Poore and Nemecek 2018; Xu et al. 2021). Dietary change is therefore increasingly highlighted as an important and necessary mitigation option for food system sustainability (e.g., Clark et al. 2020; IPBES 2019; IPCC 2019; Roe et al. 2021). Moreover, while the proposed diet changes were more cautious some years ago, suggesting shifts from grain-fed beef consumption to poultry, pork, or pasture-fed beef (e.g., Foley et al. 2011), more recent recommendations tend to be bolder in reflecting the need for a more radical shift towards a diet rich in plant-based proteins, with far fewer animal source foods (FAO/WHO 2019; Willett et al. 2019). Yet, there are very few calls for a global transition to a vegan diet (animal rights advocates excepted). For instance, increasing the consumption of some animal products is identified as a solution towards improving the nutritional status of some of the world's poorest (FAO 2018a). Other scholars claim that livestock can have substantial benefits, such as those derived for biodiversity from sustainably managed grazing, improved livelihoods, or the maintenance of socio-cultural landscapes (Gerber et al. 2013; Kamilaris et al. 2020; Röös et al. 2016). This illustrates that the concept of "sustainable meat consumption" is far from being straightforward.

Europeans are currently among the world's biggest meat consumers. In 2020, per-capita meat consumption in the EU was 68 kg (retail weight), more than twice the global average, with the consumption projections for 2030 remaining virtually steady (OECD/FAO 2021).[1] While strong action would be needed to halt these meat consumption trends, the F2F arguably fails to tackle the issue effectively (Jackson et al. 2021; König and Araújo-Soares 2021). Although the F2F acknowledges that the transition towards a sustainable food system needs a shift in people's diets: "a more plant-based diet with less red and processed meat and with more

[1] Data extracted from OECD Agriculture statistics database. Refer to http://dx.doi.org/10.1787/agr-outl-data-en. (Accessed in November 2021).

fruits and vegetables" (EC 2020a, p. 12), no specific targets are set for meat consumption.

In practice, there are very few examples of governments implementing measures to steer meat consumption towards sustainable diets (Röös et al. 2021) other than some dietary guidelines that include environmental concerns (e.g., DVFA 2021). However, a substantial literature suggests that information-based measures alone are insufficient to accomplish major shifts in people's diets (Brambila-Macias et al. 2011; König and Araújo-Soares 2021; SAPEA 2020). This is partly explained by the power dynamics across the food system, which cannot be adequately addressed by focusing solely on consumer choice or individual responsibility (Fuchs et al. 2016; Jackson et al. 2021). While demand-side policies are increasingly suggested (Bonnet et al. 2020; Fesenfeld et al. 2020; Guyomard et al. 2021; Moran and Blair 2021; Röös et al. 2021), the political will to engage in such policies has been largely absent. As Wellesley et al. (2015) note, governments seem to be trapped in a cycle of inertia, fearing the repercussions of stronger interventions, yet comforted by the low public awareness of the detrimental impacts of meat consumption (EC 2020c; Macdiarmid et al. 2016; Sanchez-Sabate and Sabaté 2019). In this sense, the challenge remains to provide scientifically sound and socially acceptable targets for meat consumption that would allow people to better understand the policy rationale of more stringent interventions, and thereby, as Wellesley et al. (2015) suggest, reduce the risk of public backlash.

This article proposes an innovative conceptual framework to define meat consumption targets aimed at informing more ambitious policy interventions. We first describe the gaps in existing definitions of "sustainable meat consumption". We then present the concept of consumption corridors (CCs) and explain how it could be suitable to define meat targets in the Green Deal context. Subsequently, we propose a conceptual framework for defining a corridor of "sustainable meat consumption". Finally, we discuss some of the main challenges related to the implementation of such a framework.

Defining "sustainable meat consumption": what are the gaps?

Need for consistent meat consumption targets

Defining quantified targets to characterize "sustainable meat consumption" can be more effective to drive diet change than more general calls like "eat less meat" or "eat more greens" (Bareket-Bojmel et al. 2020). However, existing meat consumption targets are neither consistent nor comprehensive enough to provide a sound basis for decision-making (Resare Sahlin et al. 2020). Most national dietary guidelines in the EU recommend limiting red meat and/or meat consumption, without necessarily defining a maximum quantity, or else recommendations vary, with some recommendations based on health concerns only, and some based on both health and (to some extent) environmental concerns.[2] For instance, in line with the health-based recommendations from the World Cancer Research Fund (WCRF 2018), the French dietary guidelines suggest limiting red meat consumption to 500 g per week (Santé publique France 2019), while the Danish guidelines (based on health and climate impacts) recommend limiting the consumption of not just red meat, but of all types of meat to 350 g per week (DVFA 2021). Meanwhile, several NGOs have been calling the EU to set binding targets to reduce meat consumption according to their own assessments. For instance, Greenpeace calls for a 71% reduction in the EU by 2030, and 81% by 2050, compared to 2017 levels.[3] This lack of consistency between different meat consumption targets complicates both collective and individual action.

Need for a holistic framework to define "sustainable" meat

Most of the studies on sustainable diets assess only some environmental aspects—usually impacts on climate change and land-use change (e.g., Jones et al. 2016). A few studies have focused specifically on biodiversity and nature conservation (e.g., Henry et al. 2019), while others introduce the health perspective (e.g., Tilman and Clark 2014) and include aspects, such as nutritional adequacy, nutrient bioavailability, and diet cost (Barré et al. 2018; Perignon et al. 2016; Wilson et al. 2019). One of the most concrete attempts to define sustainable dietary targets at the global scale has been undertaken by the EAT–*Lancet* Commission (Willett et al. 2019). This group of scientists developed a reference diet based on extensive literature on foods, dietary patterns, and health outcomes. Then, considering planetary boundaries (Rockström et al. 2009; Steffen et al. 2015), they defined the "safe operating space for food systems". They ultimately showed that, in combination with food production improvements and food waste reduction, the food system based on the reference diet would remain within that safe operating space.

To define "sustainable meat consumption", such studies would need to be complemented with important sustainability considerations, which, for the case of meat, include the ethical issues involved in livestock production, antibiotic

[2] Food-based dietary guidelines, available in the FAO webpage. Refer to: https://www.fao.org/nutrition/education/food-based-dietary-guidelines. (Accessed in November 2021).

[3] Refer to: https://www.greenpeace.org/eu-unit/issues/nature-food/2664/eu-climate-diet-71-less-meat-by-2030/. (Accessed in November 2021).

use, and farmers' livelihoods (Resare Sahlin et al. 2020), or the qualitative aspects of meat, which are influenced by culture and tradition and differ depending on geographical location (Priolo et al. 2001). In fact, it has been argued that defining "sustainable meat" would require an integrated assessment that includes a wide range of sustainability priorities (Resare Sahlin et al. 2020). Using narrow definitions runs the risk of neglecting "other substantial sustainability priorities and trade-offs, leading to improvements in one area while worsening the outcome in others, which could result in mere shifting of sustainability challenges rather than overall gains" (Resare Sahlin et al. 2020, p. 522).

Furthermore, current food system and environmental impact models tend to mostly represent the supply side of food production, and often prescribe the demand side through stylized scenarios such as a sharp reduction in the consumption of some types of meat, or a shift to vegetarian or vegan diets (e.g., Henry et al. 2019; Poore and Nemecek 2018). Arguably, such modelling approaches fail to engage sufficiently with the social sciences (beyond economics) and the humanities. There is hence a disconnect between the assessment of environmental impacts and the literature on sustainable consumption, which often results in fragmented solutions. Yet, the importance of integrating insights from the natural and social sciences in a holistic framework to address food systems sustainability (EC 2020d), and meat consumption in particular (Godfray et al. 2018), has been widely acknowledged. As Moran and Blair (2021) argue, if as individuals or a society we choose to eat meat, we should do so with the clearest view of the costs and benefits of our decision, using a framework that facilitates the commensurability of impacts and articulates a clearer and more comprehensive definition of sustainability.

Need for strong stakeholder engagement

In general, targets for global environmental governance derived solely from experts' knowledge, without public participation, have been widely criticized (e.g., Bäckstrand 2003; Welp et al. 2006). For diet change specifically, the F2F (EC 2020a) and the World Health Organization (WHO 2021), among many others, recommend the use of participatory approaches in addressing the implementation gap between research and practice to define sustainable diets. The concept of "sustainable meat consumption", in particular, includes normative elements that entail major trade-offs between the different sustainability dimensions of meat production and consumption (Resare Sahlin et al. 2020). Such a balancing act is based not only on facts, but also on value judgments.

Participatory approaches are recommended for such complex or wicked problems, where uncertainties and stakes are high and scientific expertise falls short when confronted with the diversity of value choices (Funtowicz and Ravetz 1994). When such choices are driven by stakeholders, they lead to better societal outcomes (Newig et al. 2019) subsequently implemented with less conflict (Voinov and Bousquet 2010). In this context, transdisciplinary research approaches can provide useful methodologies for eliciting and integrating stakeholders' knowledge, goals, and values in both scientific and societal processes (Lang et al. 2012).

Need for context-specific meat consumption targets

Defining targets for "sustainable meat consumption" immediately raises questions about the geographical scope. A possible approach is to downscale global targets to a specific country or region. For instance, Moberg et al. (2020) benchmarked the Swedish average diet against the global boundaries defined by the EAT–*Lancet* Commission (Willett et al. 2019) and found that it breached all but the water boundary, hence showing that it is highly unsustainable. Although useful for communication purposes, downscaling global targets comes with numerous challenges, including how to divide the resource use or emissions space across citizens or countries (Biermann and Kim 2020). Theories of distributive justice challenge the equal per-capita sharing of the "safe operating space", calling for more complex models that can include other concerns such as welfare or capabilities (Ryberg et al. 2020). In this respect, additional efforts might be needed in European countries, where meat consumption is already high and healthy alternative foods are available. Furthermore, meat consumption is determined by factors, such as culture, demographics, urbanization, income, prices, religion, and tradition (OCDE/FAO 2021). It is also influenced by the less visible power exerted by the meat industry, through marketing, for instance (Fuchs et al. 2016).

The above strongly suggests that context-specific meat consumption targets (and policies to achieve them) would be far more relevant, fair, and easily enacted than global targets. The Green Deal provides a unique opportunity to embed those targets in an overarching policy framework, thereby enhancing institutional coherence and likelihood of implementation. The subsequent section introduces the concept of consumption corridors (CCs) that could possibly help establish targets for meat consumption in the context of the Green Deal.

Applying the concept of corridors of sustainable consumption

Consumption corridors (CCs) constitute an innovative approach that is gaining traction in the literature on sustainable consumption governance (Fuchs 2020; Fuchs et al.

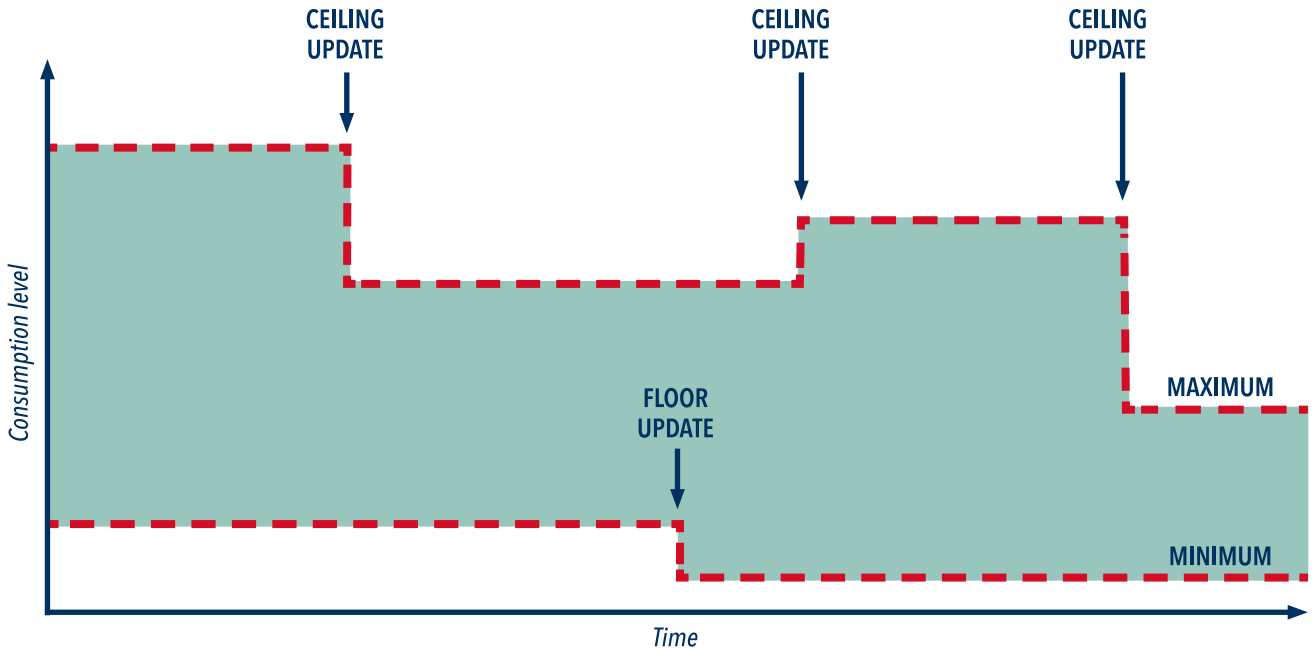

Fig. 1 Illustration of a consumption corridor. Adapted from (Di Giulio and Fuchs 2014, p. 187). Consumption levels can refer to a level of aggregate or per-capita consumption depending upon the context of application

2021; Sahakian et al. 2021). At the general conceptual level, Kanerva (2022) introduces the idea of using CCs for the case of meat.

This section first highlights the main features of the CCs' approach, and then explains how CCs can help address the gaps identified above and inform policy development in the Green Deal context.

CCs combine planetary sustainability and social wellbeing

A CC is the space between a minimum (the floor) and maximum (the ceiling) consumption level, which allows everybody to satisfy their needs without compromising others' ability to meet their own (Fuchs 2020). The corridor floor is meant to guarantee access to sufficient resources for all (Gumbert and Bohn 2021) and determines what every individual must be provided with to lead a valuable life (Di Giulio and Defila 2021). The corridor ceiling is set at a level to prevent the consumption of some individuals adversely impacting the ability of others (alive now or in the future) to satisfy their needs (Di Giulio and Defila 2021). CCs thus demarcate a sustainable space in which individuals are free to consume as they wish (Fuchs 2020). While the floor is justified by a social idea of human wellbeing, the ceiling derives from an ecological principle of planetary sustainability (Gough 2020). It is precisely this combination of social and environmental boundaries that lays the foundations for a holistic framework to define "sustainable meat consumption".

Figure 1 illustrates a corridor of sustainable consumption and how it might evolve over time. The minima and maxima consumption levels are subject to periodical negotiations (Di Giulio and Fuchs 2014) to adapt, for example, to cultural shifts (e.g., increased concern for animal welfare resulting in a renegotiated lower floor), technological developments (e.g., increased efficiency resulting in a renegotiated higher ceiling), or new knowledge (e.g., new data on aggravated environmental impacts of meat production resulting in a renegotiated lower ceiling), among others.

CCs focus on consumption

Similar to the previous models that have prevailed in the sustainability governance literature (Raworth 2017; Rockström et al. 2009), CCs pursue the aim of human wellbeing in a world of limited resources. What makes CCs a novel approach is their focus on consumption as one of the root causes of unsustainability. Following this approach, to respect planetary and social boundaries, overconsumption needs to be limited and under-consumption needs to be addressed (Fuchs 2020). By focusing on consumption, CCs downplay the dominant "eco-efficiency" paradigm (Gough 2020), which lies at the heart of the Green Deal and aims to transform the EU into an economy "where economic growth is decoupled from resource use" (EC 2019, p. 2). Recognizing that decoupling cannot be the sole means of transitioning to a sustainable

economy is especially relevant for the case of meat, as reductions in resource use and emissions associated with meat production are difficult to achieve through technological advances alone (Buckwell and Nadeu 2018; Röös et al. 2017; Springmann et al. 2018). Given the vast scale of decoupling required and the little time left for the transition (Parrique et al. 2019), demand-side solutions (e.g., Creutzig et al. 2018; Fuso Nerini et al. 2021) are increasingly proposed to counterbalance this singular focus on the supply side. CCs belong to this family of approaches which build on the notion of allocating limited resources and emission space "fairly" across world citizens. However, CCs also consider the potential improvements in production, as both supply and demand-side mitigation options are used when defining the ceiling of the corridor. They hence enable the combination of the efficiency and sufficiency perspectives (Garnett 2014).

CCs embrace equity and justice

The notion of justice is at the very core of CCs. By taking a stand for a stronger governance of consumption (Fuchs 2020; Lorek and Fuchs 2013), CCs are designed to tackle several forms of injustice, ranging from the impacts of the global North on the global South, to social and intergenerational justice. In a world where, for example, the richest 1% of the population (63 million people) are responsible for twice the amount of cumulative emissions as the poorest 50% (3.1 billion people) (Oxfam 2020), issues of distributional justice cannot be dissociated from those of sustainable human wellbeing (Gough 2020). Rich countries have outsourced a considerable part of food production, and related environmental burdens, to the global South (Fuchs et al. 2020), creating a mismatch between consumption-based and production-based emissions. By focusing our attention on consumption, regardless of where production takes place, CCs provide a more equitable alternative to discuss what is actually a "fair share" of the world's limited resources. This responds to the increasing calls from the academic community to link planetary boundaries to human consumption (Li et al. 2021; O'Neill et al. 2018; Wiedmann et al. 2020), and to reconcile global equity and environmental sustainability (Biermann and Kim 2020; Raworth 2017). Moreover, by recognizing the existence of universal needs, including those of future generations, CCs also take social and intergenerational justice into account. In this respect, consumption choices can be free only insofar as they do not hinder others' chances of satisfying their needs, now and in the future (Di Giulio and Defila 2021).

CCs are based on transdisciplinary science

The CCs' literature emphasizes the importance of participatory approaches. CCs cannot be dictated top–down, but they stem from a "dual strategy" (Gough 2020; Guillen-Royo 2020), including both codified "expert knowledge" and the "experiential knowledge" of those whose needs are under consideration. The "expert knowledge" needs to be embedded in an integrated approach that is not lopsidedly informed by natural or social sciences, but is convincing from an inter-disciplinary view-point (Di Giulio and Defila 2021). Similarly, the "experiential knowledge" would require engagement in societal debates and participative democracy, including a variety of actors and considering different contexts (Sahakian et al. 2021). The ambition of such participatory approaches is to tackle the deepest leverage points for sustainability transformation (Abson et al. 2017; Meadows 1999) by addressing the "intent" of a system, i.e., the norms, values, goals, and their underlying paradigms (Defila and Di Giulio 2020).

One of the most innovative aspects of CCs in this context is that they truly challenge various predominant paradigms, from economic and green growth, to expert-driven science and consumer sovereignty. For example, by redefining consumption as the act of meeting the universal needs of all peoples in a fair way, personal consumption becomes an issue of social engagement and public policy (Gough 2020). This profound paradigm shift can be legitimate only if collectively decided by citizens through public deliberation (Gumbert and Bohn 2021).

Using CCs to define meat targets in the EU

Considering the above, CCs provide a well-thought-out framework to establish consistent targets for "sustainable meat consumption". In addition, they propose an approach that is especially appropriate in the context of the Green Deal. First, the Green Deal's ambition to "leave no one behind" advocates for a just and inclusive transition including for those "most vulnerable and the more exposed to harmful effects of climate change and environmental degradation" (EC 2019, p. 16). CCs are attuned to this principle, at the EU and beyond. They have the potential to go further than current environmental impact models, to integrate social concerns focusing on equity and justice. In an EU CC, the lower boundaries are meant to guarantee sufficient resources for all EU citizens. The upper boundaries intend to tackle climate and food injustice, and to avoid exporting environmental damage to non-EU countries. CCs have hence the potential to support not only the Green Deal within the EU, but also its ambition to contribute to the Sustainable Development Goals (EC 2019, p. 3). What CCs make plain is that, in a world of limited natural and social resources, embracing the existence of universal and incontestable needs goes hand in hand with the idea of regulating consumption (Di Giulio and Defila 2021).

Second, the Green Deal recognizes that "game changing policies only work if citizens are fully involved in designing them" (EC 2019, p. 22). The CCs' call for a transdisciplinary approach fully acknowledges this concern. Public participation to define a CC is not just a means to achieve socially accepted targets, but it is a necessity, to operate a profound paradigm shift away from overconsumption in affluent societies. CCs, moreover, offer a promising avenue to temper public discourses around meat, which are highly polarized. Today, reconciling the interests of the livestock industry with, for instance, the pledges of animal advocacy organizations seems an intractable task. Meat consumption is also an emotionally charged (Weenink and Spaargaren 2016) and contradictory issue for many consumers who are averse to harming animals but, at the same time, like eating meat (the so-called "meat paradox") (Loughnan et al. 2010; Nijland 2016). By legitimizing a space for "sustainable meat consumption", CCs could foster a new narrative in which the meat/no-meat dichotomy (Jallinoja et al. 2016; Kanerva 2021) could at least partially dissolve.

Towards an integrated framework to define a corridor of "sustainable meat consumption"

To date, there have been only a few partial empirical attempts at operationalizing the concept of CCs (e.g., Godin et al. 2020; Lavelle and Fahy 2021; Vladimirova 2021). An integrated approach is therefore still needed. In this section, we build on CC philosophy and propose a conceptual framework for the case of meat consumption.

Our approach, rooted in transdisciplinary science, does not allow us to operationalize the framework in this article, since defining the meat CC involves navigating multiple trade-offs that require public consultation. Hence, for now, we provide a roadmap to guide the discussions with stakeholders, in which we identify the key sustainability aspects needed to define the corridor's ceiling and floor. For this exercise, we take into account the Green Deal's policy and build on insights from the literature on sustainable food systems, sustainable consumption, sustainability transformation, and other disciplinary fields specifically involved in sustainable meat production and consumption.

Characteristics of the conceptual framework

While some holistic frameworks have been proposed for food systems as a whole (Fanzo et al. 2020; HLPE 2017), no standardized model exists for the specific case of meat consumption in high-income countries. We fill this gap following a systems' approach (FAO 2018b; von Braun et al. 2021; EC 2020d) to suggest a conceptual framework for defining "sustainable meat consumption" in a manner that can cut across disciplinary boundaries.

The starting point is to establish the type of knowledge and perspectives needed to define the upper and lower limits of the meat CC. These need to be rooted in the international standard for "sustainable healthy diets" which: "promote all dimensions of individuals' health and wellbeing; have low environmental pressure and impact; are accessible, affordable, safe, and equitable; and are culturally acceptable" (FAO/WHO 2019, p. 9). In this definition, it is possible to identify the three most common dimensions of sustainability frameworks: social (including nutrition and health), environmental, and economic. However, meat consumption impacts more than planetary and human wellbeing. Production animals are in the frontline of food systems—arguably, more so than humans. Discussions which, for example, turn them into mere "proteins" to satisfy human nutrition, or "numbers" to fit onto available land, tend to overlook the complex moral dilemmas at play. Such simplistic narratives contribute to keeping our "meat" separated from any idea that there was once an animal (Adams 1990) with consciousness (Low et al. 2012), agency (Donaldson and Kymlicka 2011), and the capability to flourish (Nussbaum 2006). This is why our proposed conceptual framework, besides social, environmental, and economic considerations, explicitly includes the animal ethics dimension. It thereby attempts to respond to an increasing societal concern about animal welfare (Alonso et al. 2020; EC 2016), and to include those who convey such concern in the participatory definition of the corridor.

In alignment with our interpretation of the CC philosophy, the meat consumption ceiling should be determined primarily by the limits to production from an environmental perspective, and the floor should be informed by human needs—in the case of meat, foremost, by a nutrition perspective. However, a holistic definition of "sustainable meat consumption" needs to consider a more complex spectrum of the different sustainability dimensions. This is why, in the proposed conceptual framework, the meat consumption ceiling is to be determined by any sustainability aspect for which there is a reason to limit meat consumption. This includes mainly a range of environmental aspects, but there are also other reasons, such as health, to limit meat consumption (e.g., overconsumption of red and processed meat that has been associated with several diseases). Similarly, the floor should be determined by all sustainability aspects deemed relevant for setting a minimum level of meat consumption. These include nutrition but also, for instance, some environmental aspects (e.g., the use of grasslands) which contribute positively to food system environmental sustainability. Further detail of the sustainability aspects that are key to inform the ceiling and floor is given in the roadmaps below.

The meat CC should be rooted in the fundamental distinction between universal "needs" and specific "need satisfiers"

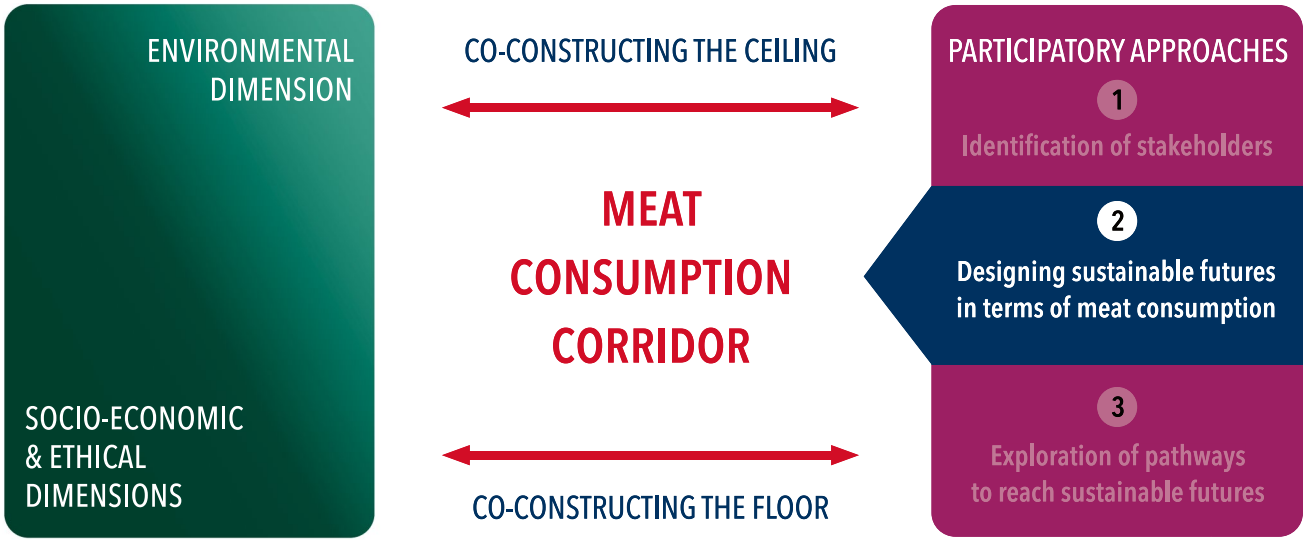

Fig. 2 Conceptual framework to define a corridor of "sustainable meat consumption"

(Doyal and Gough 1991). While "needs" (e.g., food, shelter, participation) are limited, non-negotiable and apply to all people (Gough 2020, p. 212), "need satisfiers" refer to the countless and variable ways in which individuals can fulfill those needs in particular contexts (Gough 2020, p. 212). As emphasized in Gough (2020), CCs are an attempt not to restrict basic needs (i.e., nutritious and healthy diets), but to redefine the boundaries of need satisfiers in affluent societies (i.e., how much meat is considered sustainable in the EU context). Including this perspective in the corridor can pave the way for moving from food as a commodity to food as a common good (Vivero-Pol et al. 2018). This shift challenges the idea of food as a purely private good and puts sustainability at the center of the analysis (Jackson et al. 2021). This is important, since the F2F has been criticized for framing food as a commodity, and such framing may shape food policies and their impact in the wrong direction (Jackson et al. 2021).

Participatory approaches should be key in determining the meat CC. The literature on CCs tends to emphasize public deliberation on the identification of minimum (i.e., the floor) consumption standards (Fuchs 2020; Gough 2020). In our framework, we argue for the need for the wider use of participation, in which stakeholders also take part in defining the underlying system conceptualizations in resource and environmental models (i.e., the ceiling). Turning thus to participatory modelling (e.g., Voinov et al. 2016) departs from a simplistic understanding of environmental limits, as if these were the sole property of nature rather than the result of assumptions and choices made in biophysical models (Kallis 2019). It provides a space for researchers to present the potential trade-offs and to co-design desirable futures with stakeholders (e.g., Karlsson et al. 2018).

Figure 2 illustrates the conceptual framework. Its operationalization will require public consultation. Determining floors and ceilings derives thus from a multi-actor collaboration, where experts interact with stakeholders to define the final outcomes. The definitions of the ceiling and the floor are, respectively, led by environmental and social considerations. However, in practice, no clear line can be drawn to entirely split the different sustainability dimensions between the ceiling and the floor. For instance, environmental concerns come into play when defining both the ceiling and the floor, as there are reasons to both limit and promote a certain amount of meat consumption based on this dimension. The same applies to the health dimension. This fuzziness is represented in the figure by the gradation of the green color at the intersection between the different sustainability dimensions, and concrete examples are given below in the roadmaps for defining the ceiling and floor.

This conceptual framework entails two main caveats. First, a full approach to CCs does not only involve the definition of targets (Step 2 in Fig. 2). Participatory processes should also identify the most relevant actors (Step 1) and discuss the policies and other means needed to achieve those targets (Step 3). While the figure includes the three necessary steps to operationalize the corridor, this article focuses on Step 2, namely designing sustainable futures, i.e., defining the ceiling and the floor of the meat CC. Throughout the article, we inevitably touch on some aspects related to the other steps, but expanding on them more deeply is beyond the scope of this paper. Second, the conceptual framework does not aim to provide a comprehensive view on diet change. Both the framework and the subsequent roadmaps are designed for meat and, therefore, include the sustainability aspects deemed relevant for this food category. A

similar approach could be used to develop a corridor for other foods (e.g., fish or dairy). Each such CC exercise would need to introduce its own roadmap for defining the ceilings and floors, based on the most relevant sustainability aspects related to each food category (some of which can be common to meat, and others not).

Roadmap for defining the ceiling

Integrating four sustainability aspects (i.e., human nutrition, pasture utilization, GHG emissions, and nitrogen flows), Buckwell and Nadeu (2018) produced initial estimates, showing that the EU livestock systems are not located within a safe operating space. To define a specific target for the ceiling of the meat CC, additional work needs to be done.

The ceiling of the meat CC would need to ensure that food systems' environmental impact remains within planetary boundaries (Willett et al. 2019). Different tools can be used to establish the ceiling. For example, mass-flow modelling (Kalt et al. 2021) could be used to capture environmental impacts and pressures from the production of meat needed to supply EU consumption, while also highlighting potential synergies and trade-offs between different environmental and other sustainability aspects. As the environmental impact of the EU meat industry spans beyond the European borders (e.g., through the use of imported feed), impacts in non-EU countries must be carefully considered. Furthermore, to avoid exporting environmental damage to other countries, in the case where meat is replaced by plant-based foods produced in non-EU regions, the ceiling also needs to account for impacts from international trade. Trade analysis could be used to explore such displacement effects taking into account the Green Deal's targets (Fuchs et al. 2020).

When the environmental pressures and impacts associated with the production of the meat needed to supply a certain level of EU-demand have been established, this has to be related to some sustainable limit to define the ceiling. For a set of environmental aspects, the EAT–*Lancet* framework (Willett et al. 2019) provides global boundaries for the food system. To apply such boundaries specifically to meat, the amount of resource use/emissions space that can be dedicated to meat in relation to other foods must be defined. Karlsson Potter and Röös (2021) were faced with a similar challenge in the development of a consumer guide. They followed an approach in which the calculated per-capita environmental space for each environmental impact category (e.g., GHG emissions, water use) was distributed over different food groups, based on their current impact on the respective environmental impact categories of a sustainable diet. This approach gave varying environmental space to different food groups, thus reflecting how food could be consumed sustainably. For instance, proteins received a greater resource use/emissions space allowance than carbohydrates, as they are usually more resource demanding to produce. This is, however, just one example of how such allowances could be determined, which would require extensive discussions between experts and relevant stakeholders.

The ceiling of the meat CC would also need to consider relevant F2F targets, such as the reduction of antibiotic use in livestock production, or improvements in animal welfare. Additional aspects such as the risk of zoonosis might also be considered relevant when designing the ceiling. However, how much meat consumption can be "accommodated" within the corridor, considering risks of antimicrobial resistance and the development of zoonosis, is a very open question. It can depend, for example, on the use of antibiotics in different production systems, the potential to reduce and improve such use, and the feasibility of highly bio-secure farms (Tang et al. 2017). A first step to enable the inclusion of those aspects into the definition of the corridor is to model such considerations for current and future scenarios. As regards animal welfare, there have been some concrete proposals for its integration into life-cycle sustainability assessments (e.g., Scherer et al. 2018). However, this aspect is rarely included in current models and entail considerable trade-offs. For instance, broiler production is often considered an efficient and low-carbon solution compared to red meat production, but it comes with significant ethical concerns related to bird welfare (Hartcher and Lum 2020).

We should note here the strong link between ruminant meat production and dairy production, as a large part of the EU ruminant meat production derives from culled dairy cows and their offspring raised for meat. Therefore, a discussion on meat cannot be entirely separated from dairy. However, our roadmap refers to meat (and not dairy) consumption, as the factors affecting them differ considerably and require different strategies to tackle the possible overconsumption of each food group (Wellesley et al. 2015).

Finally, overconsumption of red and processed meat has been directly associated with risk of obesity (Rouhani et al. 2014) and, especially for processed meat, increased risk of cardiovascular disease (Wang et al. 2016), colorectal cancer (Bouvard et al. 2015), and other non-communicable diseases such as diabetes (Wolk 2017). Therefore, the CC ceiling should also consider the health impacts of meat consumption. To determine an upper limit of meat consumption based on health considerations remains challenging and, as stated above, national dietary guidelines in the Member States are not consistent enough to offer an actual consumption ceiling for the entire EU. They vary quite ostensibly both in the way they define meat and in the suggested maximum consumption quantities (Buckwell and Nadeu 2018). However, national dietary guidelines are themselves commonly based on the recommendations arising from international bodies such as the World Cancer Research Fund (WCRF).

We suggest that such recommendations could be used as a basis, complemented with the latest available scientific knowledge, such as large prospective studies and meta-analyses assessing the health risks associated with meat consumption. Today, the conclusions of these studies (mostly available for high-income Western countries) show that mortality rates are modestly higher in participants who have high intakes of both red and processed meat than in those with low meat intakes, whereas no or moderate inverse associations have been observed for poultry (Godfray et al. 2018). This suggests the need to establish different upper consumption limits based on health for different meat products, differentiating species and potentially even type of processing (Buckwell and Nadeu 2018).

Roadmap for defining the floor

The floor of the meat CC requires a definition of the minimum standards needed to ensure that people can live a good life (Fuchs 2020). Such considerations have been made, for example, for energy (Millward-Hopkins et al. 2020; Vogel et al. 2021) and a minimum amount of living space (Cohen 2021). For meat consumption, similar work needs to be done.

Central to defining the CC floor is the role of meat for human nutrition. Vegetarian diets vary substantially, ranging from excluding all types of meat to excluding all animal products (for a categorization, see Oussalah et al. 2020, p. 3284). Evidence from large epidemiologic cohorts supports that these are all healthy diets associated with a reduction in several common disease risk factors, and reduced risk of some chronic diseases of public health importance (Orlich et al. 2019). However, vegetarian diets need to be well planned if they are to provide an overall adequate nutrient intake. They primarily need to include a reliable source of vitamin B12 (Agnoli et al. 2017), of which lower concentrations have been found among vegetarians, especially in vegan diets—i.e., only plant-based (Oussalah et al. 2020).

Close attention is also needed for the effects of vegetarian diets on age-stratified populations. More research is warranted on specific population segments, such as pregnant and lactating women, infants, children, adolescents, and the elderly (Oussalah et al. 2020, p. 3305). Based on this, we see the emergence of several possible floors for the meat CC in relation to nutrition, depending on the context and population group. These could range from no meat in diets geared towards healthy adults with access to information and alternative foods, to a certain amount of meat (to be defined) for specific population segments. The floor of the meat CC could aggregate these individual needs in different vulnerable groups (e.g., elderly, diseased), while accounting for the current eating patterns and potential risks that drastic cuts in meat consumption could have on public health. This resembles how current dietary advice is developed. To make it salient and relevant to people, the process includes both considerations of what can be considered an optimal diet from a health perspective, and how people are currently eating. The use of a CC would, however, more clearly articulate how little meat is actually "safe" to consume from a nutrition perspective. Such clarity from public health agencies could help overcome one of the barriers to reducing meat consumption, namely the lack of knowledge on the need to eat meat or not in healthy diets (Stoll-Kleemann and Schmidt 2017).

Although meat and livestock production cause many environmental problems (informing the ceiling of the corridor), meat production can, under certain circumstances, contribute positively to the environmental sustainability of food systems. For example, on some of the world's 3.4 billion ha of grasslands, food production is possible only with grazing animals. If these animals are removed, and hence, no meat is produced from grasslands, additional cropland or cropland intensification will be needed to supply equivalent protein, fats, and micronutrients (Van Zanten et al. 2018). Moreover, on some of these grasslands, grazing livestock is indispensable for biodiversity conservation (Eriksson 2021). Intensifying, and especially expanding cropland should be avoided as it could cause biodiversity degradation and carbon stock loss (Poore and Nemecek 2018). Similarly, feeding animals with food waste and agricultural by-products can relieve pressure on cropland, as approximately one-third of the global protein need could potentially be produced with such non-food-competing feeds (Van Zanten et al. 2018). Hence, the amount of meat sustainably produced from grasslands and leftover streams could define a consumption floor that considers the efficient use of land. However, using ruminants to convert biomass to meat produces substantial methane emissions contributing to climate change (UNEP/CCAC 2021). Furthermore, to protect biodiversity, some grasslands need to be managed more extensively or even be rewilded (Pereira and Navarro 2015). Negotiation is therefore needed on the numbers of ruminants that can be "allowed" from a climate and biodiversity perspective (under the CC ceiling) and the efficient use of grassland for food production to alleviate pressure on cropland (under the CC floor).

Socio-economic considerations are also an important aspect to consider when defining the floor of the meat CC. In this respect, the role of some traditional livestock farming communities that depend on extensive pasture and meadow farming systems is particularly important, as they contribute to maintaining highly biodiverse cultural landscapes (Buckwell and Nadeu 2018). These communities often find themselves in a weak position, unable to compete on an equal footing with the large food companies (SAPEA 2020). The protection of these farmers' livelihoods could be considered when defining the corridor floor. However, we

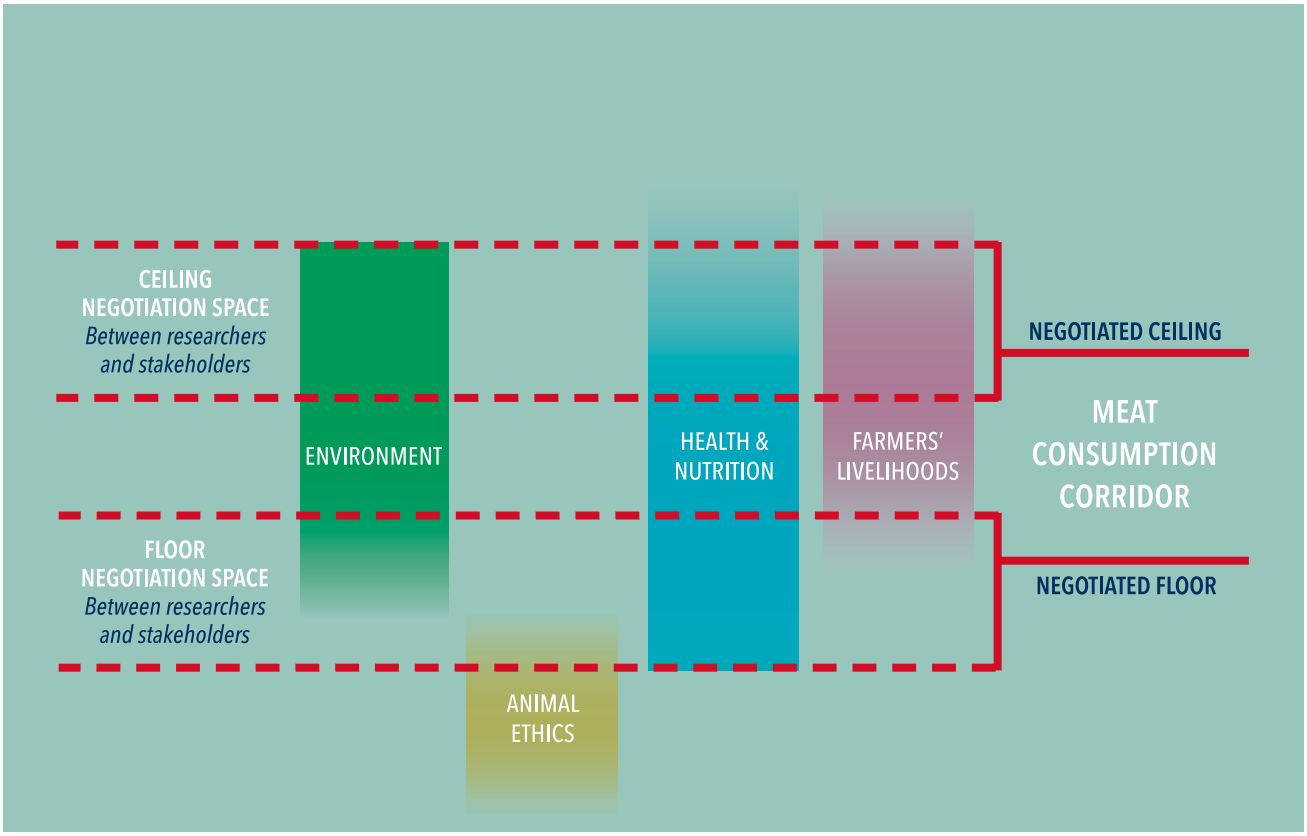

Fig. 3 Hypothetical application of the proposed conceptual framework illustrating potential trade-offs for designing sustainable futures in terms of meat consumption

should also note that while the provision of services from the livestock sector is important (e.g., Dumont et al. 2019; Rodríguez-Ortega et al. 2014), there is no objective way to define minimal levels of employment and economic activity for this sector (Buckwell and Nadeu 2018). In this context, agent-based modelling (ABM, e.g., Murray-Rust et al. 2014) could be used to evaluate which farmers are able to adapt to the Green Deal targets and which are not, since ABM focuses on simulating the behavioral processes that underpin farmer decision-making in a non-reductionist way (Brown et al. 2018). Among others, this can facilitate the identification of external interventions that could support transitions to alternative livelihoods (Rounsevell et al. 2012).

That said, the inclusion of the animal ethics perspective in the corridor complicates the justification of a meat CC floor (or a ceiling, by the same token). There is a range of views in the animal ethics literature on the extent to which livestock production is justifiable. The utilitarian and rights-based perspectives stress that animals have interests that should be weighed in our moral decisions (e.g., Singer 1975; VandeVeer 1979), and a right not to be harmed or killed unnecessarily (e.g., Cochrane 2012; Regan 1983). From these perspectives, bar some exceptions (e.g., nutrition for specific groups), meat consumption would not constitute a basic interest and, therefore, most people should refrain from consuming meat altogether. Positions among relational or care ethical theories diverge more. They include those arguing that raising animals for consumption is not in principle problematic, provided that animals are given the opportunity to express natural behavior, develop social bonds, and are killed as painlessly as possible (see Engster 2006 for an overview). However, they generally call for quite substantial reforms to the ways in which animals are commonly kept (e.g., Donovan and Adams 2007; Mellor 2016). Overall, from an animal ethics perspective, there is an inherent tension with defining both lower and upper limits for meat consumption that should be acknowledged within the frame of an inclusive participatory approach that includes all relevant stakeholders to the debate.

Handling trade-offs

Figure 3 illustrates some of the key trade-offs involved in the definition of the meat CC, in a hypothetical application of the framework. All sustainability dimensions would have their own ceilings and floors, represented through the

hypothetical lengths of the different bars in the figure. However, this does not mean that they all play a similar role in the negotiation space with stakeholders. Negotiations to define the (maximum) ceiling are led by the environmental dimension (i.e., global environmental pressures and impacts to supply EU meat consumption), with other key aspects to define the ceiling including relevant Green Deal targets (e.g., reduction of antibiotic use) and health considerations (negative impacts of meat consumption on health). Negotiations to define the (minimum) floor of meat consumption are led by the nutrition perspective. Other key dimensions to define the floor include environmental aspects (e.g., food production from grazing animals benefitting biodiversity), farmers' livelihoods, and the animal ethics perspectives. The resulting trade-offs between the different sustainability dimensions need to be collectively negotiated through stakeholder participation. Different kinds of multi-criteria decision-making methods (Zavadskas et al. 2014) could be used to facilitate such negotiations. Such methods could help assist in reaching a final decision, as they provide structured ways to articulate and resolve trade-offs when different dimensions and stakeholders are involved.

CCs can be a "tool for systemic social change" (Pirgmaier 2020, p. 278). They suggest a clear direction for desirable changes, as they are embedded in a powerful set of principles, including (a) recognizing universal needs, (b) tackling both over- and under-consumption, (c) framing food as a common good, (d) promoting public participation, and (e) addressing environmental justice and planetary sustainability.

Thus, the resulting trade-offs and synergies need to be balanced in light of these overarching principles. This means that, for instance, the CC ceiling cannot bow to the narrative of economic profit postulated by the agro-industry. It is clear that any serious attempt to develop targets for meat consumption needs to consider the effects on employment and profitability of the industry. However, these cannot reign at the expense of planetary sustainability. This challenges one of the dominant narratives in the food system, whereby economic competitiveness is one of the main goals against which trade-offs are weighed (EC 2020d). Following this narrative, the high yields generated by intensive food production systems, in which meat is produced at low costs, are seen as synergistic with food security. However, intensified food production systems are associated with environmental challenges due to, for instance, widespread use of monocultures and pesticides. Such intensified systems also tend to neglect the social and economic situation of small-scale producers and rural communities (EC 2020d).

In contrast to this dominant narrative, in the proposed conceptual framework, the meat consumption ceiling is to be defined considering environmental concerns over economic competitiveness. Therefore, the emerging trade-offs can be arguably handled in a way that is more conducive to sustainability transformation. Meanwhile, food security and socioeconomic considerations can be duly considered when defining the meat consumption floor. The key here is shifting the dominant discourses (e.g., meat needs to be produced at low costs to ensure food security) along with the associated norms and values. In this regard, the participatory approaches leading to the definition of the meat CC should pay special attention to the inclusion of bottom–up marginalized perspectives. Including these perspectives is key to ensure a power-sensitive negotiation process and to reveal systemic power constellations protecting the status quo (Pirgmaier 2020).

Main challenges for the implementation of the conceptual framework

Engaging with powerful and marginalized actors

Participation has been defined as "processes in which individuals take part in decision-making that affects them" (Wandersman 1981, cited in Blackstock et al. 2007, p. 728). It typically involves individuals who are otherwise not entrusted with decision-making power (Renn 2005). One of the most common criticisms of participatory processes is that they can override existing and legitimate decision-making structures and promote group dynamics that tend to reproduce the interests of the powerful elites. Cooke and Kothari (2001) describe this as the "tyranny" of participation. Achieving inclusion in this context is a balancing act in which both the powerful and the marginalized are brought together (Kok et al. 2021). The established and well-connected actors (e.g., industry, policy-makers) are needed to ensure the impacts of the process, for instance, by providing credibility to the outcomes and linking them to policy measures. The under-represented actors (e.g., citizens/consumer groups, small farmers, and NGOs) can contribute to this process by providing legitimacy, increasing societal support, and by broadening dominant perspectives (Kok et al. 2021).

Inclusion is especially important for the transformation of the food system (Bui et al. 2019) where power asymmetries, including the vested interests of big agri-food corporations, have been widely documented (Fuchs et al. 2016; Morgan et al. 2008; Yates et al. 2021). It has been argued that concentrated corporate power in the food system tends to shape the direction of change in ways that maintain the status quo, hindering transformation towards more sustainable and inclusive outcomes (Conti et al. 2021). We know, for instance, that a previous version of the F2F strategy

explicitly proposed to "stop stimulating the production or consumption of meat",[4] while the final version compromised on "support to the most sustainable, carbon-efficient methods of livestock production" (EC 2020a, p. 10).

The literature exploring the role of power in shaping the outcomes of participatory processes offers some valuable suggestions to neutralize power imbalances. For example, Barnaud et al. (2010) suggest performing an initial stakeholder analysis (and their interests and socio-political context), as a means of anticipating potential obstacles to achieve an equitable and concerted process, and essentially identify mitigation options through the prior adaptation of methods and tools. Wollenberg et al. (2001) argue that trying to reach consensus too fast often fails to tackle power inequities, emphasizing on the need to go beyond an initial apparent consensus that often reflects the interests of the most powerful. To avoid superficial compromises, alongside plenary discussions, individual interviews and small group discussions can provide all the participants the opportunity to freely express and further articulate their opinions (Barnaud et al. 2010). Other scholars claim that orientation towards consensus constrains diversity and inclusiveness and, therefore, it should not be the principal guiding logic of co-production (Díaz-Reviriego et al. 2019). Accommodating pluralism, contestation, informed dissent, and difference should also be a paramount goal of participatory processes (Turnhout et al. 2020). Some even praise the value of conflict itself, as a form of participation, since it gives voice to emergent positions and groups that challenge dominant institutions (Cuppen 2018). Overall, what this literature recommends is to recognize politics and power as an inherent part of the co-production process (Turnhout et al. 2020). This entails negotiations that openly discuss power issues, making power asymmetries more explicit and reflecting on the often implicit assumptions and expectations about each other's roles and responsibilities (Mansbridge et al. 2010, cited in Turnhout et al. 2020, p. 17).

Acknowledging cultural acceptability and other intangible human needs associated with meat consumption

Cultural food adequacy is receiving increasing attention in the literature on food systems (Bené et al. 2019). While the criteria to qualify this dimension are still unclear, they require, as a minimum, the recognition of social and cultural values associated with food, which go far beyond nutrition (Béné et al. 2019). This is important for the case of meat, as often the normative standards and beliefs about the levels and types of meat consumption are culturally loaded and need to be contextualized (Nguyen and Platow 2021). Yet, it has been acknowledged that there is no scientific way to determine the boundaries of meat consumption based on cultural preferences (Buckwell and Nadeu 2018). A possible approach to overcome this challenge is to define an overall corridor at the EU level, in which the ceiling and the floor apply to the EU as a whole. Then, the corridor could be broken down for each Member State, according to criteria that acknowledge the cultural diversity of European foods and diets. This would entail negotiations in which Member States would have to make their fair share of the effort to respect the overall EU corridor.

At the individual level, meat consumption is not just a satisfier for nutrition but also fulfills other needs such as identity or social belonging (Kanerva 2022; Nguyen and Platow 2021). Including such considerations when defining the floor of the meat CC would make the calculations far more complex. The fact that CCs impose not a single target, but a consumption space, leaves room for these various other needs to be fulfilled. As long as their satisfaction does not cross the CC ceiling, they can be fully recognized in the space within the corridor, where individuals are free to consume as they wish.

Considering spatial dynamics

While our framework makes it possible to identify how much meat production might be needed to satisfy human needs and protect livelihoods within environmental limits, it is not intended to identify where this production should take place (neither within nor outside the EU). This raises questions about the spatial dimensions of the meat CC, especially as it pertains to the attribution of the environmental pressures and impacts associated with meat production, some of which (e.g., the use of water or land, or emissions of excess nutrients) are highly location specific (Vanham et al. 2019). For instance, in some regions in Europe, high concentrations of intensive livestock production cause serious problems with the eutrophication of waterways (Garnier et al. 2016). The location of meat production is also highly relevant when evaluating impacts on livelihoods, since cultural contexts vary geographically. In this sense, a good understanding of the actual location where the impacts of meat production happen is crucial when designing production-side mitigation options.

The extent to which this should inform the spatial attribution of the meat CC is, however, questionable. In our framework, although both meat production and consumption are considered, a clear distinction between the two is made. When considering the concerns for equity and justice that lay at the heart of CCs, in principle, it would not be acceptable to attribute a higher meat consumption "allowance" to a Member State that has, for instance, greater water and land availability, or waterways which are less vulnerable to

[4] Refer to: https://www.politico.eu/wp-content/uploads/2020/05/FarmtoForkMay001.pdf. p. 11.

eutrophication. Therefore, although the overall environmental impact assessment needs to acknowledge specific meat production contexts, the capacity to produce meat with lower impacts in a certain Member State would not necessarily imply a higher environmental consumption ceiling for this Member State. The same rationale would apply to the floor where, for instance, the extent of grasslands in a given Member State should not necessarily be associated with a higher meat consumption floor. This is one of the ways in which the CC's emphasis on consumption over production opens new avenues to discuss more equitable alternatives to characterize "sustainable meat consumption".

Conclusion

This article presents a conceptual framework to steer meat consumption in a more sustainable direction. Based on CCs, it offers a new narrative that can guide both science and policy. From the scientific perspective, the inter-disciplinary nature of the framework affords an overview of the connections across the multiple perspectives linked to the characterization of "sustainable meat consumption". From the policy perspective, it has the potential to increase policy coherence across the highly fragmented areas (agriculture, nutrition, health, trade, climate, environment, energy, and competition) currently involved in meat consumption and production. Based on public participation and attuned to the Green Deal's ambition to "leave no one behind", such a framework could strengthen the policy rationale to implement the much-needed demand-side measures to reduce meat consumption.

We acknowledge the complexity of the task. However, complexity should not be an opportunity for interest groups to cloud the issue, or for science and policy to settle for shallow solutions. As the authors who coined the concept of CCs argue (Fuchs et al. 2021, p. 67), as long as problems keep on being framed as a sole function of inefficient technologies or poor individual choices, we will return to the same tired solutions, to the detriment of the bolder possibilities needed to achieve real sustainability transformation.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

Abson DJ, Fischer J, Leventon J, Newig J, Schomerus T, Vilsmaier U, von Wehrden H, Abernethy P, Ives CD, Jager NW, Lang DJ (2017) Leverage points for sustainability transformation. Ambio 46(1):30–39. https://doi.org/10.1007/s13280-016-0800-y

Adams C (1990) The sexual politics of meat. A feminist-vegetarian critical theory. The Continuum International, New York

Agnoli C, Baroni L, Bertini I, Ciappellano S, Fabbri A, Papa M, Pellegrini N, Sbarbati R, Scarino ML, Siani V, Sieri S (2017) Position paper on vegetarian diets from the working group of the Italian Society of Human Nutrition. Nutr Metab Cardiovasc Dis 27(12):1037–1052. https://doi.org/10.1016/j.numecd.2017.10.020

Alonso ME, González-Montaña JR, Lomillos JM (2020) Consumers' concerns and perceptions of farm animal welfare. Animals 10(3):385. https://doi.org/10.3390/ani10030385

Bäckstrand K (2003) Civic science for sustainability: reframing the role of experts, policy-makers and citizens in environmental governance. Global Environ Polit 3(4):24–41. https://doi.org/10.1162/152638003322757916

Bareket-Bojmel L, Grinstein A, Steinhart Y (2020) Embrace the debate: goals, de-marketing overconsumption, and conflicting information. Psychol Mark 37(11):1484–1497. https://doi.org/10.1002/mar.21394

Barnaud C, van Paassen A, Trébuil G, Promburom T, Bousquet F (2010) Dealing with power games in a companion modelling process: lessons from community water management in Thailand highlands. J Agric Educ Ext 16(1):55–74. https://doi.org/10.1080/13892240903533152

Barré T, Perignon M, Gazan R, Vieux F, Micard V, Amiot M-J, Darmon N (2018) Integrating nutrient bioavailability and co-production links when identifying sustainable diets: how low should we reduce meat consumption? PLoS ONE 13(2):e0191767. https://doi.org/10.1371/journal.pone.0191767

Barreiro-Hurle J, Bogonos M, Himics M, Hristov J, Perez Dominguez I, Sahoo A, Salputra G, Weiss F, Baldoni E, Elleby C (2021) Modelling environmental and climate ambition in the agricultural sector with the CAPRI model (No. JRC121368). Joint Research Centre https://doi.org/10.2760/98160

Béné C, Oosterveer P, Lamotte L, Brouwer ID, de Haan S, Prager SD, Talsma EF, Khoury CK (2019) When food systems meet sustainability—current narratives and implications for actions. World Dev 113:116–130

Beckman J, Ivanic M, Jelliffe JL, Baquedano FG, Scott SG (2020) Economic and Food Security Impacts of Agricultural Input Reduction Under the European Union Green Deal's Farm to Fork and Biodiversity Strategies (No. 1473-2020-1039). United States Department of Agriculture (USDA). Economic Research Service. Economic Brief Number 30. https://ageconsearch.umn.edu/record/307277/

Biermann F, Kim RE (2020) The boundaries of the planetary boundary framework: a critical appraisal of approaches to define a "safe operating space" for humanity. Annu Rev Environ Resour 45(1):497–521. https://doi.org/10.1146/annurev-environ-012320-080337

Blackstock KL, Kelly GJ, Horsey BL (2007) Developing and applying a framework to evaluate participatory research for sustainability. Ecol Econ 60(4):726–742. https://doi.org/10.1016/j.ecolecon.2006.05.014

Bonnet C, Bouamra-Mechemache Z, Réquillart V, Treich N (2020) Viewpoint: regulating meat consumption to improve health, the environment and animal welfare. Food Policy 97:101847. https://doi.org/10.1016/j.foodpol.2020.101847

Bouvard V, Loomis D, Guyton KZ, Grosse Y, Ghissassi FE, Benbrahim-Tallaa L, Guha N, Mattock H, Straif K (2015) Carcinogenicity of consumption of red and processed meat. Lancet Oncol 16(16):1599–1600. https://doi.org/10.1016/S1470-2045(15)00444-1

Brambila-Macias J, Shankar B, Capacci S, Mazzocchi M, Perez-Cueto FJA, Verbeke W, Traill WB (2011) Policy interventions to promote healthy eating: a review of what works, what does not, and what is promising. Food Nutr Bull 32(4):365–375. https://doi.org/10.1177/156482651103200408

Brown C, Holzhauer S, Metzger MJ, Paterson JS, Rounsevell M (2018) Land managers' behaviours modulate pathways to visions of future land systems. Reg Environ Change 18(3):831–845. https://doi.org/10.1007/s10113-016-0999-y

Buckwell A, Nadeu E (2018) What is the safe operating space for EU livestock. The RISE Foundation, Brussels. https://risefoundation.eu/wp-content/uploads/2020/07/2018_RISE_Livestock_Full.pdf

Bui S, Costa I, De Schutter O, Dedeurwaerdere T, Hudon M, Feyereisen M (2019) Systemic ethics and inclusive governance: two key prerequisites for sustainability transitions of agri-food systems. Agric Hum Values 36(2):277–288. https://doi.org/10.1007/s10460-019-09917-2

Clark M, Macdiarmid J, Jones AD, Ranganathan J, Herrero M, Fanzo J (2020) The role of healthy diets in environmentally sustainable food systems. Food Nutr Bull 41(2 suppl):31S-58S. https://doi.org/10.1177/0379572120953734

Cochrane A (2012) Animal rights without liberation: Applied ethics and human obligations. Columbia University Press, New York

Cohen MJ (2021) New conceptions of sufficient home size in high-income countries: are we approaching a sustainable consumption transition? Hous Theory Soc 38(2):173–203. https://doi.org/10.1080/14036096.2020.1722218

Conti C, Zanello G, Hall A (2021) Why are agri-food systems resistant to new directions of change? A systematic review. Glob Food Sec 31:100576. https://doi.org/10.1016/j.gfs.2021.100576

Cooke B, Kothari U (2001) Participation: the new tyranny? Zed Books, London

Creutzig F, Roy J, Lamb WF, Azevedo IML, Bruine de Bruin W, Dalkmann H, Edelenbosch OY, Geels FW, Grubler A, Hepburn C, Hertwich EG, Khosla R, Mattauch L, Minx JC, Ramakrishnan A, Rao ND, Steinberger JK, Tavoni M, Ürge-Vorsatz D, Weber EU (2018) Towards demand-side solutions for mitigating climate change. Nat Clim Chang 8(4):260–263. https://doi.org/10.1038/s41558-018-0121-1

Cuppen E (2018) The value of social conflicts. Critiquing invited participation in energy projects. Energy Res Social Sci 38:28–32. https://doi.org/10.1016/j.erss.2018.01.016

Defila R, Di Giulio A (2020) The concept of "consumption corridors" meets society: how an idea for fundamental changes in consumption is received. J Consum Policy 43(2):315–344. https://doi.org/10.1007/s10603-019-09437-w

Di Giulio A, Defila R (2021) Building the bridge between Protected Needs and consumption corridors. Sustain Sci Pract Policy 17(1):118–135. https://doi.org/10.1080/15487733.2021.1907056

Di Giulio A, Fuchs D (2014) Sustainable consumption corridors: concept, objections, and responses. GAIA - Ecol Perspect Sci Soc 23(3):184–192. https://doi.org/10.14512/gaia.23.S1.6

Díaz-Reviriego I, Turnhout E, Beck S (2019) Participation and inclusiveness in the intergovernmental science-policy platform on biodiversity and ecosystem services. Nat Sustain 2(6):457–464. https://doi.org/10.1038/s41893-019-0290-6

Donaldson S, Kymlicka W (2011) Zoopolis: a political theory of animal rights. Oxford University Press

Donovan J, Adams C (eds) (2007) The feminist care tradition in animal ethics. Columbia University Press, New York

Doyal L, Gough I (1991) A theory of human need. Palgrave Macmillan, Basingstoke

Dumont B, Ryschawy J, Duru M, Benoit M, Chatellier V, Delaby L, Donnars C, Dupraz P, Lemauviel-Lavenant S, Méda B, Vollet D, Sabatier R (2019) Review: associations among goods, impacts and ecosystem services provided by livestock farming. Animal 13(8):1773–1784. https://doi.org/10.1017/s1751731118002586

DVFA (2021) The Official Dietary Guidelines – good for health and climate. The Danish Veterinary and Food Administration (DVFA). Ministry of Food, Agriculture and Fisheries of Denmark. https://altomkost.dk/fileadmin/user_upload/altomkost.dk/Publikationsdatabase/De_officielle_Kostraad_2021/Danish_Official_Dietary_Guidelines_Good_for_Health_and_climate_2021_SCREEN_ENG.pdf

EC (2016) Special Eurobarometer 442: Attitudes of Europeans towards Animal Welfare. Directorate-General for Health and Food Safety. https://europa.eu/eurobarometer/surveys/detail/2096

EC (2019) Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. The European Green Deal. COM(2019) 640 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2019:640:FIN

EC (2020a) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system. COM/2020a/381 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020aDC0381

EC (2020b) Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. EU Biodiversity Strategy for 2030: Bringing nature back into our lives. COM(2020b) 380 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020bDC0380

EC (2020c) Special Eurobarometer 505: Making our food fit for the future – Citizens' expectations. Directorate-General for Health and Food Safety. https://europa.eu/eurobarometer/surveys/detail/2241

EC (2020d) Towards a Sustainable Food System. Scientific Advice Mechanism (SAM). Independent Expert Report from the Group of Chief Scientific Advisors. Scientific Opinion n°8, March 2020d. Directorate-General for Research and Innovation. https://op.europa.eu/en/web/eu-law-and-publications/publication-detail/-/publication/ca8ffeda-99bb-11ea-aac4-01aa75ed71a1

EC (2021) Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. New EU Forest Strategy for 2030. COM(2021) 572 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0572

Engster D (2006) Care ethics and animal welfare. J Social Philos 37(4):521–536. https://doi.org/10.1111/j.1467-9833.2006.00355.x

Eriksson O (2021) The importance of traditional agricultural landscapes for preventing species extinctions. Biodivers Conserv 30(5):1341–1357. https://doi.org/10.1007/s10531-021-02145-3

EU (2021) Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law'). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32021R1119

Fanzo J, Haddad L, McLaren R, Marshall Q, Davis C, Herforth A, Jones A, Beal T, Tschirley D, Bellows A, Miachon L, Gu Y, Bloem M, Kapuria A (2020) The Food Systems Dashboard is a

new tool to inform better food policy. Nat Food 1(5):243–246. https://doi.org/10.1038/s43016-020-0077-y
FAO (2018a) World Livestock: transforming the livestock sector through the sustainable development goals. Rome. https://doi.org/10.4060/ca1201en
FAO (2018b) Sustainable food systems. Concept and framework. Rome. https://www.fao.org/3/ca2079en/CA2079EN.pdf
FAO/WHO (2019) Sustainable healthy diets—Guiding principles. Rome. https://www.fao.org/3/ca6640en/ca6640en.pdf
Fesenfeld LP, Wicki M, Sun Y, Bernauer T (2020) Policy packaging can make food system transformation feasible. Nat Food 1(3):173–182. https://doi.org/10.1038/s43016-020-0047-4
Foley JA, Ramankutty N, Brauman KA, Cassidy ES, Gerber JS, Johnston M, Mueller ND, O'Connell C, Ray DK, West PC, Balzer C, Bennett EM, Carpenter SR, Hill J, Monfreda C, Polasky S, Rockström J, Sheehan J, Siebert S, Tilman D, Zaks DPM (2011) Solutions for a cultivated planet. Nature 478(7369):337–342. https://doi.org/10.1038/nature10452
Fuchs D (2020) Living well within limits: The vision of consumption corridors. *Routledge Handbook of Global Sustainability Governance*, 1st edn. Routledge
Fuchs R, Brown C, Rounsevell M (2020) Europe's Green Deal offshores environmental damage to other nations. Nature 586(7831):671–673. https://doi.org/10.1038/d41586-020-02991-1
Fuchs D, Di Giulio A, Glaab K, Lorek S, Maniates M, Princen T, Røpke I (2016) Power: the missing element in sustainable consumption and absolute reductions research and action. J Clean Prod 132:298–307. https://doi.org/10.1016/j.jclepro.2015.02.006
Fuchs D, Sahakian M, Gumbert T, Di Giulio A, Maniates M, Lorek S, Graf A (2021) Consumption corridors. Living a good life within sustainable limits, 1st edn. Routledge
Funtowicz SO, Ravetz JR (1994) Uncertainty, complexity and post-normal science. Environ Toxicol Chem 13(12):1881–1885. https://doi.org/10.1002/etc.5620131203
Fuso Nerini F, Fawcett T, Parag Y, Ekins P (2021) Personal carbon allowances revisited. Nat Sustain. https://doi.org/10.1038/s41893-021-00756-w
Garnett T (2014) Three perspectives on sustainable food security: efficiency, demand restraint, food system transformation. What role for life cycle assessment? J Clean Prod 73:10–18. https://doi.org/10.1016/j.jclepro.2013.07.045
Garnier J, Anglade J, Benoit M, Billen G, Puech T, Ramarson A, Passy P, Silvestre M, Lassaletta L, Trommenschlager J-M, Schott C, Tallec G (2016) Reconnecting crop and cattle farming to reduce nitrogen losses to river water of an intensive agricultural catchment (Seine basin, France): past, present and future. Environ Sci Policy 63:76–90. https://doi.org/10.1016/j.envsci.2016.04.019
Gerber PJ, Steinfeld H, Henderson B, Mottet A, Opio C, Dijkman J, Falcucci A, Tempio G (2013) Tackling climate change through livestock - A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO). https://www.fao.org/3/i3437e/i3437e.pdf
Godfray HCJ, Aveyard P, Garnett T, Hall JW, Key TJ, Lorimer J, Pierrehumbert RT, Scarborough P, Springmann M, Jebb SA (2018) Meat consumption, health, and the environment. Science 361(6399):eaam5324. https://doi.org/10.1126/science.aam5324
Godin L, Laakso S, Sahakian M (2020) Doing laundry in consumption corridors: wellbeing and everyday life. Sustain Sci Pract Policy 16(1):99–113. https://doi.org/10.1080/15487733.2020.1785095
Gough I (2020) Defining floors and ceilings: the contribution of human needs theory. Sustain Sci Pract Policy 16(1):208–219. https://doi.org/10.1080/15487733.2020.1814033
Guillen-Royo M (2020) Applying the fundamental human needs approach to sustainable consumption corridors: participatory workshops involving information and communication technologies. Sustain Sci Pract Policy 16(1):114–127. https://doi.org/10.1080/15487733.2020.1787311
Gumbert T, Bohn C (2021) Are liberal objections to consumption corridors justified? On the relation of freedom and limits in green liberal thought. Sustain Sci Pract Policy 17(1):91–102. https://doi.org/10.1080/15487733.2021.1878733
Guyomard H, Bouamra-Mechemache Z, Chatellier V, Delaby L, Détang-Dessendre C, Peyraud JL, Réquillart V (2021) Review: why and how to regulate animal production and consumption: the case of the European Union. Animal 15:100283. https://doi.org/10.1016/j.animal.2021.100283
Hartcher KM, Lum HK (2020) Genetic selection of broilers and welfare consequences: a review. Worlds Poult Sci J 76(1):154–167. https://doi.org/10.1080/00439339.2019.1680025
Henning C, Witzke P (2021) Economic and environmental impacts of the green deal on the agricultural economy: a simulation study of the impact of the F2F-Strategy on production, trade, welfare and the environment based on the CAPRI-Model. Executive Summary. Grain Club. https://grain-club.de/fileadmin/user_upload/Dokumente/Farm_to_fork_Studie_Executive_Summary_EN.pdf
Henry RC, Alexander P, Rabin S, Anthoni P, Rounsevell MDA, Arneth A (2019) The role of global dietary transitions for safeguarding biodiversity. Glob Environ Chang 58:101956. https://doi.org/10.1016/j.gloenvcha.2019.101956
HLPE (2017) Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. https://www.fao.org/cfs/accueil-du-hlpe/rapports/report-12-elaboration-process/fr/
IPBES (2019). Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Brondizio ES, Settele J, Díaz S, Ngo HT (eds). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.3831673
IPCC (2019) Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management,food security,and greenhouse gas fluxes in terrestrial ecosystems [P.R.Shukla, J.Skea, E.Calvo Buendia, V.Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. https://www.ipcc.ch/srccl/
Jackson P, Rivera Ferre MG, Candel J, Davies A, Derani C, de Vries H, Dragović-Uzelac V, Hoel AH, Holm L, Mathijs E, Morone P, Penker M, Śpiewak R, Termeer K, Thøgersen J (2021) Food as a commodity, human right or common good. Nature Food 2(3):132–134. https://doi.org/10.1038/s43016-021-00245-5
Jallinoja P, Niva M, Latvala T (2016) Future of sustainable eating? Examining the potential for expanding bean eating in a meat-eating culture. Futures 83:4–14. https://doi.org/10.1016/j.futures.2016.03.006
Jones AD, Hoey L, Blesh J, Miller L, Green A, Shapiro LF (2016) A systematic review of the measurement of sustainable diets. Adv Nutr (bethesda, Md) 7(4):641–664. https://doi.org/10.3945/an.115.011015
Kallis G (2019) Limits: Why Malthus was wrong and why environmentalists should care. Standford University Press, Stanford
Kalt G, Mayer A, Haberl H, Kaufmann L, Lauk C, Matej S, Röös E, Theurl MC, Erb K-H (2021) Exploring the option space for land system futures at regional to global scales: the diagnostic agro-food, land use and greenhouse gas emission model BioBaM-GHG 2.0. Ecol Model 459:109729. https://doi.org/10.1016/j.ecolmodel.2021.109729
Kamilaris C, Dewhurst RJ, Sykes AJ, Alexander P (2020) Modelling alternative management scenarios of economic and

environmental sustainability of beef finishing systems. J Clean Prod 253:119888. https://doi.org/10.1016/j.jclepro.2019.119888
Kanerva M (2021) The new meatways and sustainability: discourses and social practices. Bielefeld, Germany: Transcript Verlag. https://doi.org/10.1515/9783839454336
Kanerva M (2022) Consumption corridors and the case of meat. J Consum Policy. https://doi.org/10.1007/s10603-022-09524-5
Karlsson Potter H, Röös E (2021) Multi-criteria evaluation of plant-based foods –use of environmental footprint and LCA data for consumer guidance. J Clean Prod 280:124721. https://doi.org/10.1016/j.jclepro.2020.124721
Karlsson JO, Carlsson G, Lindberg M, Sjunnestrand T, Röös E (2018) Designing a future food vision for the Nordics through a participatory modeling approach. Agron Sustain Dev 38(6):59. https://doi.org/10.1007/s13593-018-0528-0
Kok KPW, Gjefsen MD, Regeer BJ, Broerse JEW (2021) Unraveling the politics of 'doing inclusion' in transdisciplinarity for sustainable transformation. Sustain Sci 16(6):1811–1826. https://doi.org/10.1007/s11625-021-01033-7
König LM, Araújo-Soares V (2021) Will the Farm to Fork strategy be effective in changing food consumption behaviour? A health psychology perspective. Appl Econ Perspect Policy. https://doi.org/10.1002/aepp.13220
Lang DJ, Wiek A, Bergmann M, Stauffacher M, Martens P, Moll P, Swilling M, Thomas CJ (2012) Transdisciplinary research in sustainability science: practice, principles, and challenges. Sustain Sci 7(1):25–43. https://doi.org/10.1007/s11625-011-0149-x
Lavelle MJ, Fahy F (2021) Creating context for corridors of consumption: the case of Ireland. Sustain Sci Pract Policy 17(1):62–76. https://doi.org/10.1080/15487733.2020.1864966
Li M, Wiedmann T, Fang K, Hadjikakou M (2021) The role of planetary boundaries in assessing absolute environmental sustainability across scales. Environ Int 152:106475. https://doi.org/10.1016/j.envint.2021.106475
Lorek S, Fuchs D (2013) Strong sustainable consumption governance – precondition for a degrowth path? J Clean Prod 38:36–43. https://doi.org/10.1016/j.jclepro.2011.08.008
Loughnan S, Haslam N, Bastian B (2010) The role of meat consumption in the denial of moral status and mind to meat animals. Appetite 55(1):156–159. https://doi.org/10.1016/j.appet.2010.05.043
Low P, Panksepp J, Reiss D, Edelman D, Van Swinderen B, Koch C (2012) The Cambridge Declaration on Consciousness https://philiplow.foundation/data/uploads/cambridge/CambridgeDeclarationOnConsciousness.pdf
Macdiarmid JI, Douglas F, Campbell J (2016) Eating like there's no tomorrow: public awareness of the environmental impact of food and reluctance to eat less meat as part of a sustainable diet. Appetite 96:487–493. https://doi.org/10.1016/j.appet.2015.10.011
Meadows DH (1999) Leverage points: places to intervene in a system. The Sustainability Institute, Hartland, VT
Mellor DJ (2016) Updating animal welfare thinking: moving beyond the "five freedoms" towards "a life worth living." Animals 6(3):21
Millward-Hopkins J, Steinberger JK, Rao ND, Oswald Y (2020) Providing decent living with minimum energy: a global scenario. Glob Environ Chang 65:102168. https://doi.org/10.1016/j.gloenvcha.2020.102168
Moberg E, Karlsson Potter H, Wood A, Hansson P-A, Röös E (2020) Benchmarking the Swedish diet relative to global and national environmental targets - identification of indicator limitations and data gaps. Sustainability 12(4):1407. https://doi.org/10.3390/su12041407
Moran D, Blair KJ (2021) Review: sustainable livestock systems: anticipating demand-side challenges. Animal 15:100288. https://doi.org/10.1016/j.animal.2021.100288
Morgan K, Marsden T, Murdoch J (2008) Worlds of food: place, power, and provenance in the food chain. Oxford University Press. https://doi.org/10.1093/oso/9780199271580.001.0001
Murray-Rust D, Brown C, van Vliet J, Alam SJ, Robinson DT, Verburg PH, Rounsevell M (2014) Combining agent functional types, capitals and services to model land use dynamics. Environ Model Softw 59:187–201. https://doi.org/10.1016/j.envsoft.2014.05.019
Mansbridge J, Bohman J, Chambers S, Estlund D, Føllesdal A, Fung A, Lafont C, Manin B, Martí JL (2010) The place of self-interest and the role of power in deliberative democracy. J Polit Philos 18:64–100. https://doi.org/10.1111/j.1467-9760.2009.00344.x
Newig J, Jahn S, Lang DJ, Kahle J, Bergmann M (2019) Linking modes of research to their scientific and societal outcomes. Evidence from 81 sustainability-oriented research projects. Environ Sci Policy 101:147–155. https://doi.org/10.1016/j.envsci.2019.08.008
Nguyen A, Platow MJ (2021) "I'll eat meat because that's what we do": the role of national norms and national social identification on meat eating. Appetite 164:105287. https://doi.org/10.1016/j.appet.2021.105287
Nijland H (2016) Disentangling the domestic contract: understanding the everyday-life construction of acceptability -or non-acceptability- of keeping and killing animals for food. Doctoral dissertation, Wageningen University
Nussbaum MC (2006) Frontiers of justice : disability, nationality, species membership. Belknap Press, Cambridge, MA
OECD, FAO, (2021) OECD-FAO Agricultural Outlook 2021–2030. OECD Publishing, Paris. https://doi.org/10.1787/19428846-en
O'Neill DW, Fanning AL, Lamb WF, Steinberger JK (2018) A good life for all within planetary boundaries. Nat Sustain 1(2):88–95. https://doi.org/10.1038/s41893-018-0021-4
Orlich MJ, Chiu THT, Dhillon PK, Key TJ, Fraser GE, Shridhar K, Agrawal S, Kinra S (2019) Vegetarian epidemiology: review and discussion of findings from geographically diverse cohorts. Adv Nutr 10(Supplement 4):S284–S295. https://doi.org/10.1093/advances/nmy109
Oussalah A, Levy J, Berthezène C, Alpers DH, Guéant J-L (2020) Health outcomes associated with vegetarian diets: an umbrella review of systematic reviews and meta-analyses. Clin Nutr 39(11):3283–3307. https://doi.org/10.1016/j.clnu.2020.02.037
OXFAM (2020) Confronting carbon inequality: Putting climate justice at the heart of the COVID-19 recovery. Oxfam Media Briefing. https://oxfamilibrary.openrepository.com/bitstream/handle/10546/621052/mb-confronting-carbon-inequality-210920-en.pdf
Parrique T, Barth J, Briens F, Kerschner C, Kraus-Polk A, Kuokkanen A, Spangenberg JH (2019). Decoupling debunked. Evidence and arguments against green growth as a sole strategy for sustainability. European Environmental Bureau. https://eeb.org/library/decoupling-debunked/
Pereira HM, Navarro LM (2015) Rewilding European landscapes. Springer Nature. https://doi.org/10.1007/978-3-319-12039-3
Perignon M, Vieux F, Soler L-G, Masset G, Darmon N (2016) Improving diet sustainability through evolution of food choices: review of epidemiological studies on the environmental impact of diets. Nutr Rev 75(1):2–17. https://doi.org/10.1093/nutrit/nuw043
Pirgmaier E (2020) Consumption corridors, capitalism and social change. Sustain Sci Pract Policy 16(1):274–285. https://doi.org/10.1080/15487733.2020.1829846
Poore J, Nemecek T (2018) Reducing food's environmental impacts through producers and consumers. Science 360(6392):987–992. https://doi.org/10.1126/science.aaq0216
Priolo A, Micol D, Agabriel J (2001) Effects of grass feeding systems on ruminant meat colour and flavour. A review. Anim Res 50(3):185–200. https://doi.org/10.1051/animres:2001125

Raworth K (2017) A Doughnut for the Anthropocene: humanity's compass in the 21st century. Lancet Planet Health 1(2):e48–e49. https://doi.org/10.1016/s2542-5196(17)30028-1

Regan T (1983) The case for animal rights. University of California Press, Berkeley

Renn O (2005) Partizipation–ein schillernder Begriff: Reaktion auf drei Beiträge zum Thema. GAIA-Ecol Perspect Sci Soc 14(3):227–228

Resare Sahlin K, Röös E, Gordon LJ (2020) 'Less but better' meat is a sustainability message in need of clarity. Nat Food 1(9):520–522. https://doi.org/10.1038/s43016-020-00140-5

Rockström J, Steffen W, Noone K, Persson Å, Chapin FS, Lambin EF, Lenton TM, Scheffer M, Folke C, Schellnhuber HJ, Nykvist B, de Wit CA, Hughes T, van der Leeuw S, Rodhe H, Sörlin S, Snyder PK, Costanza R, Svedin U, Falkenmark M, Karlberg L, Corell RW, Fabry VJ, Hansen J, Walker B, Liverman D, Richardson K, Crutzen P, Foley JA (2009) A safe operating space for humanity. Nature 461(7263):472–475. https://doi.org/10.1038/461472a

Rodríguez-Ortega T, Oteros-Rozas E, Ripoll-Bosch R, Tichit M, Martín-López B, Bernués A (2014) Applying the ecosystem services framework to pasture-based livestock farming systems in Europe. Animal 8(8):1361–1372. https://doi.org/10.1017/S1751731114000421

Roe S, Streck C, Beach R, Busch J, Chapman M, Daioglou V, Deppermann A, Doelman J, Emmet-Booth J, Engelmann J, Fricko O, Frischmann C, Funk J, Grassi G, Griscom B, Havlik P, Hanssen S, Humpenöder F, Landholm D, Lomax G, Lehmann J, Mesnildrey L, Nabuurs G-J, Popp A, Rivard C, Sanderman J, Sohngen B, Smith P, Stehfest E, Woolf D, Lawrence D (2021) Land-based measures to mitigate climate change: potential and feasibility by country. Glob Change Biol 27(23):6025–6058. https://doi.org/10.1111/gcb.15873

Röös E, Bajželj B, Smith P, Patel M, Little D, Garnett T (2017) Greedy or needy? Land use and climate impacts of food in 2050 under different livestock futures. Glob Environ Chang 47:1–12. https://doi.org/10.1016/j.gloenvcha.2017.09.001

Röös E, Larsson J, Sahlin KR, Jonell M, Lindahl T, André E, Säll S, Harring N, Persson M (2021) Policy Options for Sustainable Food Consumption – Review and Recommendtions for Sweden (Mitra Sustainable Consumption report 1:10 2021). https://www.sustainableconsumption.se/wp-content/uploads/sites/34/2021/03/Policy-Options-for-Sustainable-Food-Consumption-2021-Mistra-Sustainable-Consumption-report-1.pdf

Röös E, Patel M, Spångberg J, Carlsson G, Rydhmer L (2016) Limiting livestock production to pasture and by-products in a search for sustainable diets. Food Policy 58:1–13. https://doi.org/10.1016/j.foodpol.2015.10.008

Rouhani MH, Salehi-Abargouei A, Surkan PJ, Azadbakht L (2014) Is there a relationship between red or processed meat intake and obesity? A systematic review and meta-analysis of observational studies. Obes Rev 15(9):740–748. https://doi.org/10.1111/obr.12172

Rounsevell MDA, Robinson DT, Murray-Rust D (2012) From actors to agents in socio-ecological systems models. Philos Trans R Soc b: Biol Sci 367(1586):259–269. https://doi.org/10.1098/rstb.2011.0187

Ryberg MW, Andersen MM, Owsianiak M, Hauschild MZ (2020) Downscaling the planetary boundaries in absolute environmental sustainability assessments – a review. J Clean Prod 276:123287. https://doi.org/10.1016/j.jclepro.2020.123287

Sahakian M, Fuchs D, Lorek S, Di Giulio A (2021) Advancing the concept of consumption corridors and exploring its implications. Sustain Sci Pract Policy 17(1):305–315. https://doi.org/10.1080/15487733.2021.1919437

Santé Publique France (2019) L'essentiel des recommandations sur l'alimentation. https://www.santepubliquefrance.fr/determinants-de-sante/nutrition-et-activite-physique/documents/depliant-flyer/l-essentiel-des-recommandations-sur-l-alimentation

Sanchez-Sabate R, Sabaté J (2019) Consumer attitudes towards environmental concerns of meat consumption: a systematic review. Int J Environ Res Public Health 16(7):1220. https://doi.org/10.3390/ijerph16071220

SAPEA (2020) A sustainable food system for the European Union. Science Advice for Policy by European Academies. https://doi.org/10.26356/sustainablefood

Scherer L, Tomasik B, Rueda O, Pfister S (2018) Framework for integrating animal welfare into life cycle sustainability assessment. Int J Life Cycle Assess 23(7):1476–1490. https://doi.org/10.1007/s11367-017-1420-x

Singer P (1975) Animal liberation: a new ethics for the treatment of animals. New York Review, New York

Springmann M, Clark M, Mason-D'Croz D, Wiebe K, Bodirsky BL, Lassaletta L, de Vries W, Vermeulen SJ, Herrero M, Carlson KM, Jonell M, Troell M, DeClerck F, Gordon LJ, Zurayk R, Scarborough P, Rayner M, Loken B, Fanzo J, Godfray HCJ, Tilman D, Rockström J, Willett W (2018) Options for keeping the food system within environmental limits. Nature 562(7728):519–525. https://doi.org/10.1038/s41586-018-0594-0

Steffen W, Richardson K, Rockström J, Cornell SE, Fetzer I, Bennett EM, Biggs R, Carpenter SR, Vries Wd, Wit CAd, Folke C, Gerten D, Heinke J, Mace GM, Persson LM, Ramanathan V, Reyers B, Sörlin S (2015) Planetary boundaries: guiding human development on a changing planet. Science 347(6223):1259855. https://doi.org/10.1126/science.1259855

Stoll-Kleemann S, Schmidt UJ (2017) Reducing meat consumption in developed and transition countries to counter climate change and biodiversity loss: a review of influence factors. Reg Environ Change 17(5):1261–1277. https://doi.org/10.1007/s10113-016-1057-5

Tang KL, Caffrey NP, Nóbrega DB (2017) Restricting the use of antibiotics in food-producing animals and its associations with antibiotic resistance in food-producing animals and human beings: a systematic review and meta-analysis. Lancet Planetary Health 1(8):e316–e327. https://doi.org/10.1016/S2542-5196(17)30141-9

Tilman D, Clark M (2014) Global diets link environmental sustainability and human health. Nature 515(7528):518–522. https://doi.org/10.1038/nature13959

Turnhout E, Metze T, Wyborn C, Klenk N, Louder E (2020) The politics of co-production: participation, power, and transformation. Curr Opin Environ Sustain 42:15–21. https://doi.org/10.1016/j.cosust.2019.11.009

UNEP/CCAC (2021) Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions. United Nations Environment Programme and Climate and Clean Air Coalition. https://www.unep.org/resources/report/global-methane-assessment-benefits-and-costs-mitigating-methane-emissions

Van Zanten HHE, Herrero M, Van Hal O, Röös E, Muller A, Garnett T, Gerber PJ, Schader C, De Boer IJM (2018) Defining a land boundary for sustainable livestock consumption. Glob Change Biol 24(9):4185–4194. https://doi.org/10.1111/gcb.14321

VanDeVeer D (1979) Interspecific justice. Inquiry 22(1–4):55–79. https://doi.org/10.1080/00201747908601866

Vanham D, Leip A, Galli A, Kastner T, Bruckner M, Uwizeye A, van Dijk K, Ercin E, Dalin C, Brandão M, Bastianoni S, Fang K, Leach A, Chapagain A, Van der Velde M, Sala S, Pant R, Mancini L, Monforti-Ferrario F, Carmona-Garcia G, Marques A, Weiss F, Hoekstra AY (2019) Environmental footprint family to address local to planetary sustainability and deliver on the SDGs. Sci Total Environ 693:133642. https://doi.org/10.1016/j.scitotenv.2019.133642

Vladimirova K (2021) Consumption corridors in fashion: deliberations on upper consumption limits in minimalist fashion challenges. Sustain Sci Pract Policy 17(1):103–117. https://doi.org/10.1080/15487733.2021.1891673

Vivero-Pol JL, Ferrando T, De Schutter O, Mattei U (eds) (2018) Routledge handbook of food as a commons. Routledge, London

Vogel J, Steinberger JK, O'Neill DW, Lamb WF, Krishnakumar J (2021) Socio-economic conditions for satisfying human needs at low energy use: an international analysis of social provisioning. Glob Environ Chang 69:102287. https://doi.org/10.1016/j.gloenvcha.2021.102287

Voinov A, Bousquet F (2010) Modelling with stakeholders. Environ Model Softw 25(11):1268–1281. https://doi.org/10.1016/j.envsoft.2010.03.007

Voinov A, Kolagani N, McCall MK, Glynn PD, Kragt ME, Ostermann FO, Pierce SA, Ramu P (2016) Modelling with stakeholders – next generation. Environ Model Softw 77:196–220. https://doi.org/10.1016/j.envsoft.2015.11.016

von Braun J, Afsana K, Fresco LO, Hassan M (Eds.) (2021) Science and Innovation for Food Systems Transformation and Summit Actions. Papers by the Scientific Group and its partners in support of the UN Food Systems Summit. ScGroup of the UNFSS (2021). https://sc-fss2021.org

Wang X, Lin X, Ouyang YY, Liu J, Zhao G, Pan A, Hu FB (2016) Red and processed meat consumption and mortality: dose–response meta-analysis of prospective cohort studies. Public Health Nutr 19(5):893–905. https://doi.org/10.1017/S1368980015002062

WCRF (2018) Recommendations and public health and policy implications. https://www.wcrf.org/sites/default/files/Recommendations.pdf

Weenink D, Spaargaren G (2016) Emotional agency navigates a world of practices. In: Spaargaren G, Weenink D, Lamers M (eds) Practice theory and research. Routledge, pp 60–84

Wellesley L, Happer C, Froggatt A (2015) Changing climate, changing diets pathways to lower meat consumption. Chatham House Report. https://www.chathamhouse.org/sites/default/files/publications/research/CHHJ3820%20Diet%20and%20climate%20change%2018.11.15_WEB_NEW.pdf

Welp M, de la Vega-Leinert A, Stoll-Kleemann S, Jaeger CC (2006) Science-based stakeholder dialogues: theories and tools. Global Environ Change 16(2):170–181. https://doi.org/10.1016/j.gloenvcha.2005.12.002

WHO (2021) Healthy and Sustainable Diets Key workstreams in the WHO European Region Factsheet. World Health Organization, Regional Office for Europe. https://apps.who.int/iris/bitstream/handle/10665/340295/WHO-EURO-2021-2192-41947-57624-eng.pdf

Wiedmann T, Lenzen M, Keyßer LT, Steinberger JK (2020) Scientists' warning on affluence. Nat Commun 11(1):3107. https://doi.org/10.1038/s41467-020-16941-y

Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, Garnett T, Tilman D, DeClerck F, Wood A, Jonell M, Clark M, Gordon LJ, Fanzo J, Hawkes C, Zurayk R, Rivera JA, De Vries W, Majele Sibanda L, Afshin A, Chaudhary A, Herrero M, Agustina R, Branca F, Lartey A, Fan S, Crona B, Fox E, Bignet V, Troell M, Lindahl T, Singh S, Cornell SE, Srinath Reddy K, Narain S, Nishtar S, Murray CJL (2019) Food in the Anthropocene: the EAT-*Lancet* Commission on healthy diets from sustainable food systems. The Lancet 393(10170):447–492. https://doi.org/10.1016/S0140-6736(18)31788-4

Wilson N, Cleghorn CL, Cobiac LJ, Mizdrak A, Nghiem N (2019) Achieving healthy and sustainable diets: a review of the results of recent mathematical optimization studies. Adv Nutr 10(Supplement 4):S389–S403. https://doi.org/10.1093/advances/nmz037

Wandersman A (1981) A framework of participation in community organisations. J Appl Behav Sci. https://doi.org/10.1177/002188638101700103

Wolk A (2017) Potential health hazards of eating red meat. J Intern Med 281(2):106–122. https://doi.org/10.1111/joim.12543

Wollenberg E, Anderson J, Edmunds D (2001) Pluralism and the less powerful: accommodating multiple interests in local forest management. Int J Agric Resour Gov Ecol 1(3–4):199–222. https://doi.org/10.1504/IJARGE.2001.000012

Xu X, Sharma P, Shu S, Lin T-S, Ciais P, Tubiello FN, Smith P, Campbell N, Jain AK (2021) Global greenhouse gas emissions from animal-based foods are twice those of plant-based foods. Nature Food 2(9):724–732. https://doi.org/10.1038/s43016-021-00358-x

Yates J, Gillespie S, Savona N, Deeney M, Kadiyala S (2021) Trust and responsibility in food systems transformation Engaging with Big Food: marriage or mirage? BMJ Glob Health 6(11):e007350. https://doi.org/10.1136/bmjgh-2021-007350

Zavadskas EK, Turskis Z, Kildienė S (2014) State of art surveys of overviews on MCDM/MADM methods. Technol Econ Dev Econ 20(1):165–179. https://doi.org/10.3846/20294913.2014.892037

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.