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How to move the transition to sustainable food consumption towards a societal tipping point

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ABSTRACT

A large-scale transition of food consumption in high-income countries is required to mitigate adverse impacts on the climate and the environment. To further understand which actions can contribute to triggering societal tipping in sustainability transitions empirical observations and a closer link to existing theories is urgently needed. We integrate renowned models of behavior change, food consumption, and marketing into the framework of positive tipping points in sustainability transitions using an empirical analysis of four case studies from Denmark. The proposed framework specifies enabling conditions, interventions, and reinforcing feedback. The case studies suggest that the factors identified from existing consumer-oriented theoretical frameworks can lead to societal tipping points. Also, the transition to sustainable food consumption requires not only engagement from all groups of actors—business/industry, policy, civil society, and consumers—but also pooling and aligning the available resources to trigger a societal tipping point. The case studies provide interesting examples of how influential single players can scale up system change. The paper concludes with a critical reflection of tipping points in sustainability transitions of the food system.

1. Introduction

Food consumption, production, and related processes are responsible for approximately one third of total global anthropogenic greenhouse gas emissions (Xu et al., 2021). Loss of biodiversity, deforestation, water and energy shortages, and ecosystem disruption are examples of negative externalities of food production (Godfray et al., 2010). At the same time, dietary trends in Western countries (i.e., diets low in vegetables, nuts, and whole grains, and high in red and processed meat) cause great health burdens, such as higher risks of cardiovascular disease, type 2 diabetes, and some types of cancer (Springmann et al., 2018; Willett et al., 2019). To stop this "global syndemic", not only a change but a profound transition of the food system is urgently needed (Swinburn et al., 2019).

Overall, the term "sustainability transition" refers to a radical change from one state of the system to another. In this context, the literature is increasingly focusing on tipping points characterized as a particular "point" in the transition where a small perturbation can trigger a large response from the system and thus initiate a radical system change.

Social sciences apply the concept of *societal* tipping points to describe fundamental systemic changes in markets, society, or politics. While tipping points discussed in the field of ecology lead to the collapse of natural systems—a prominent example being the so-called planetary boundaries that, if crossed, would lead to irreparable and unacceptable environmental and climate changes (Röckström et al., 2009)— societal tipping points discussed in the context of sustainability are positive catalyzers that move the system towards a more *favorable* state (Lenton et al., 2022). A "defining quality of such positive tipping points is that they are intentional" (Lenton et al., 2022, p. 2). This is rooted in the fact that social systems—in contrast to biophysical systems—can change within short time frames and still prosper (Mandl, 2019).

Societal tipping points can occur when a critical mass is reached; at this stage, small additional interventions can trigger large-scale change in the system. Thus, the crucial question for sustainability transitions is how to identify actions that create a critical mass and tip the status quo, i.e., which actions have the largest leverage effect in the system (Meadows and Wright, 2008).

A successful societal transition is usually accompanied by behavior change at the level of individual decision-makers. For instance, the prominent "plant-based" transition of the food system requires

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consumers to reduce their meat intake and increase the consumption of plant-based products (e.g., lentils, vegetables). Food consumption, however, is highly habituated, and consumers find it difficult to change their habits. Policy interventions by public and private entities are crucial for inducing change of consumer behavior (Michie et al., 2011). So far, existing frameworks of tipping points in sustainability transitions operate at the macro level but do not harness the existing evidence and theories on drivers and mechanisms of behavior change at the micro level of the individual consumer or citizen. Agricultural policies as well as the transition literature, have however, mainly focused on the supply side (Reisch, 2021). Only recently, the potential of targeting the demand side, and thus consumer behavior and public acceptance, has been recognized as having an enormous potential for reaching a more sustainable food system (Testa et al., 2022).

The present paper suggests that the transition literature would benefit from a theoretical underpinning of how to trigger societal tipping points in (food) consumption, and under which conditions a drastic change in (food) consumption is likely to happen. Previous research on societal transitions has mostly focused on the energy and mobility sector, and only recently have studies emerged that focus on sustainability transitions in the food sector (El Bilali, 2019). Pertaining to sustainability transitions in general, Lenton et al. (2022) put forward that the emerging literature is "rather theoretical, speculative and rarely specific enough to guide actions" (p. 2). Previous research has mainly focused on examining one example of social tipping to understand case-specific catalysts of transition processes, e.g. the transition towards electric vehicles (Nykvist and Nilsson, 2015). Dynamics in social systems are often complex and interrelated (Winkelmann et al., 2022). Achieving a system transformation, requires more than a single tipping point. Multiple tipping points in several sub-systems and among different stakeholder groups are essential for a system transformation.

The sustainability transition of the food system is an example of a complex challenge, not only for the food industry, the agricultural sector, and society in general but also for the individual consumer. Food is deeply embedded in culture, and many Western food cultures are centered on animal-based foods and foods with high amounts of sugar and fat. Consumers are thus facing a three-fold challenge (SAPEA, 2020): They are asked to change the types of food they eat (in particular less processed red meat and dairy, and more lentils, vegetables, and wholegrains); they should purchase foods from sustainable production systems (e.g. organic or other forms of eco-friendly production); and in addition, they should change food-related practices to minimize the amount of food waste in their household. That raises the question of how these far-reaching changes in consumer behavior can be fostered (SAPEA, 2020).

Due to the complexity of consumption domains such as food consumption or mobility, it is often challenging to identify the complete array of interventions required to attain a global state where consumers' consumption patterns are at a sustainable level. As such, an analysis of different successful case studies becomes crucial to identify interventions that can serve as a foundation for transformative developments.

The present paper builds on this premise and develops an operational model of tipping points for the specific case of the transition to sustainable food consumption. The paper is based on a two-fold iterative approach, combining theoretical-conceptual work with an analysis of four case studies on food consumption in Denmark. The transition towards sustainable food consumption in Denmark is still in its early phase. In selected areas, however, substantial progress towards sustainable levels of food consumption has been made, i.e., in the four areas of organic food consumption, wholegrain intake, healthy eating, and food waste reduction. At the theoretical-conceptual level, we integrate renowned models of behavior change (Michie et al., 2011; Ölander and Thøgersen, 1995), food environments (HLPE, 2017), and marketing (Kotler and Keller, 2016) into the more general tipping point framework towards global sustainability by Lenton et al. (2022). The choice of the theoretical building blocks was based on the analysis of the four case studies. The theoretical framework, in turn, served as the basis for the systematic case study analysis to identify key elements, success factors and critical points.

The remainder of this paper is structured as follows: After describing the role of societal tipping points in sustainability transitions, we present the conceptual model to identify tipping points in transitions to sustainable food consumption. Subsequently, the results of the analysis of the four case studies are presented. The paper ends with a discussion and conclusion on the importance of combining theories from different disciplines and evidence from real-world case studies to accelerate the sustainable transition of the food system.

2. Theoretical background

2.1. Societal tipping points in sustainability transitions

The concept of societal tipping points is not new. Various models and theories, originating from different academic fields and attempting to capture the underlying dynamics of societal tipping points, exist. A prominent example from the management literature is the diffusion of innovation theory (Rogers, 1995) suggesting that the adoption trajectory of new technologies and practices often follows the shape of an "S curve". A tipping point occurs when the critical mass of "innovators" and "early adopters" has adopted the innovation and the "early majority" comes on board, with the number of people adopting the innovation increasing exponentially. The prominent "multi-level perspective" (Geels et al., 2016) has been widely applied to further understand sustainability transitions in other domains, e.g., mobility systems (Nemoto et al., 2023) and low-carbon transition (Testa et al., 2022). It also supports the notion that transformation follows an "S curve" trajectory, with new phenomena slowly starting in a niche until at some point the adoption rate accelerates so that the innovation spreads at the regime level and becomes the "new normal".

The existing theories on transformation have inspired sustainability scholars to discuss whether and under which conditions "S curve" trajectories with positive societal tipping points might occur in sustainability transitions (Lenton et al., 2022). The respective literature has expanded over the years, resulting in different streams of theoretical frameworks with different foci, e.g., social technological systems focusing on the agency of policy-makers on the one side (e.g., Milkoreit et al., 2018; Aschemann-Witzel and Schulze, 2023) and social-ecological systems focusing on feedbacks triggered by numerous groups of actors on the other (e.g., Van Den Bulte and Stremersch, 2004). Lenton et al. (2022) reconcile the different streams in their framework for "operationalizing positive societal tipping points towards global sustainability".

The framework by Lenton et al. (2022) suggests that the boundary conditions of the existing system need to change, i.e., *enabling conditions* need to be in place, for a societal tipping point to occur. These enabling conditions usually do not evolve "naturally", since the incumbent system is locked into unsustainable practices. Enabling conditions need to be actively created to move the system to a tipping point. Positive tipping is reached when small *interventions* implemented by actors from the areas of policy-making, business/industry, civil society, and other important fields trigger *positive feedback loops* that accelerate a shift from one state of the system to another (see Fig. 1).

The interesting and much debated question is which interventions are most effective and efficient to move the transition towards a positive societal tipping. Lenton et al. (2022) offer what they call a "non-exhaustive list" of interventions for creating enabling conditions to trigger positive tipping. The framework by Lenton et al. (2022) addresses sustainability challenges in general and does not focus on a specific sector. The authors refer to the framework as a "research agenda" (p. 8); their "meta-framework" can—and should—be adapted to concrete sustainability challenges (e.g., energy, mobility, food),

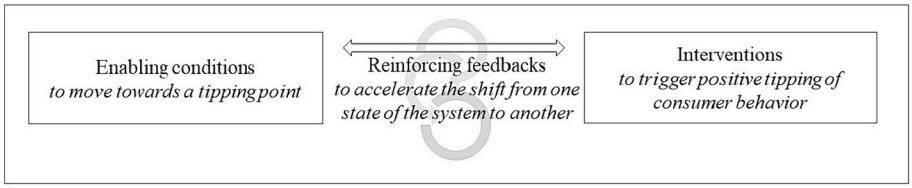

Fig. 1. Overview of underlying theoretical framework to operationalize tipping points in sustainability transitions (adapted from Lenton et al., 2022).

which means developing more specific frameworks for particular sustainability transitions. The present paper aims to contribute to this debate by developing a tipping point framework for the sustainability transition of the food system, more specifically the consumption side of the food system.

3. Conceptual model of tipping points in transitions to sustainable food consumption

Modern food consumption patterns are increasingly being criticized for its negative consequences for human health, environment and climate. As such, a shift towards more sustainable food consumption is urgently needed, which requires consumers to make specific choices and change their behavior in various ways. The FAO's definition of sustainable diets highlights the complex challenge for the individual consumer: "[Sustainable diets are] diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources." (FAO, 2016).

The food system in industrialized countries is essentially a market-based system with complex supply chains. The transition to a sustainable food system requires radical shifts of the current system, both on the demand as well as the supply side (Köhler et al., 2019). Many groups of actors need to change their behaviors and practices substantially. The type of behavior change required from individual consumers is, however, of a very different nature than the type of change required, e.g., from farmers or decision-makers in the food industry. Accordingly, the conditions which motivate consumers to buy sustainable food are to some extent different from the conditions that incentivize retailers and food companies to sell and produce sustainable food or farmers to adopt sustainable agricultural practices. Consequently, consumers should be targeted with a different set of interventions than, e.g., food companies or farmers.

Triggering positive tipping points in complex transitions like the food system transition requires in-depth knowledge of the motivations and—sometimes conflicting—interests of the different groups of stakeholders involved in the system. We thus suggest that the central elements of the general framework to operationalize tipping points by Lenton et al. (2022)—in particular *enabling conditions, positive feedback,* and *interventions*—should be specified for each group of actors, drawing upon the different strands of behavior change theories that have evolved in the disciplines of, e.g., consumer behavior, behavioral agricultural economics, and business management. The breakdown by "target groups" allows specifying the framework based on existing behavior change theories and empirical evidence from the respective disciplines. Moreover, it allows identifying lock-ins and conflicting interests in the food system.

The present paper analyses the transition to sustainable food *consumption*, i.e., it focusses on behavior change at the consumer level. The paper should be understood as a starting point of a series of analyses. It should be complemented by a similar analysis for specific sub-groups of system actors, e.g., farmers, food companies, and retailers to better understand how the transition can be fostered and how (behavior) changes required from the different groups of actors are interconnected.

3.1. Consumer behavior and (un)sustainable food consumption

Shifting to more sustainable patterns of food consumption currently requires consumers to make trade-offs (Grunert, 2011). Sustainable food is often either more expensive, less tasty, less convenient, less familiar, less common, less accepted, or a combination thereof. Research has shown that awareness of sustainability alone does not motivate a critical mass of consumers to make these trade-offs. That raises the question as to which conditions prompt consumers to shift to more sustainable patterns of food consumption, and which interventions contribute to creating "enabling conditions" for positive tipping. To answer this question, we draw on renowned literature on behavior change (Michie et al., 2011; Ölander and Thøgersen, 1995), food environments (HLPE, 2017), and marketing (Kotler and Keller, 2016) and integrate these elements as a theoretical underpinning into the model of tipping points in sustainability transitions (Lenton et al., 2022).

3.2. Enabling conditions for the consumer transition

It is uncontested that consumers have some—but not full—agency over the foods they consume. Consumers' food choices are the outcome of complex interplays between personal factors (preferences, goals, values, habits, resources, knowledge and skills, etc.), and external conditions shaped by the micro and macro environments (micro level: family, peer groups, workplace, school, etc.; macro level: social norms, food cultures, food retail landscape, food industry, food policies, etc.) (Sobal et al., 2006; SAPEA, 2020). The literature on food consumption offers two prominent frameworks that focus on the *conditions* influencing consumers' food choices, which lend themselves as theoretical underpinnings for identifying conditions for positive tipping points: (1) social psychological models of behavior change, and (2) the concept of food environments. Both streams are closely linked to the recent discourse on behavioral food policy (see e.g. Reisch, 2021) which is strongly rooted in the recognition that consumers do not make deliberate food decisions but are highly influenced by the food choice environment (Just and Gabrielyan, 2016).

3.2.1. Behavior change models

The literature on food consumption has a long tradition of identifying potential ways of how to induce behavior change among individual consumers (Hwang et al., 2021; Aschemann-Witzel and Stangherlin, 2021). Respective theoretical frameworks reflect the above-mentioned interplay between personal factors and environmental factors as important "conditions" for enabling behavior change. A prominent example is the so-called COM-B framework (Michie et al., 2011) often applied in the area of health-related behaviors, which is very similar to the MOAB-framework (Ölander and Thøgersen, 1995) developed for pro-environmental behaviors.

The COM-B framework builds on three general conditions, internal and external to the individual consumer, that may influence behavior (B): (C) capability, (O) opportunity, and (M) motivation (see Fig. 2). *Capability* refers to the psychological and physical capacity necessary for performing the behavior in question, including financial and physical resources as well as cognitive and emotional resources (Michie et al., 2011). *Opportunity* refers to external factors that facilitate or prompt the desired behavior, encompassing the two dimensions of physical and

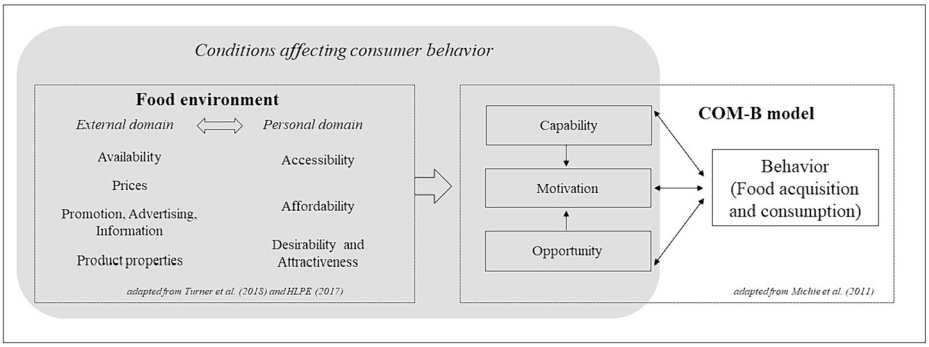

Fig. 2. Theoretical framework of enabling conditions for consumer transition.

social opportunity. *Motivation* refers to reflective and (semi-)automatic "brain processes that energise and direct behaviour" (Michie et al., 2011, p. 4). Reflective decision-making processes are linked to the personal evaluation of expected outcomes of the behavior in question (Ölander and Thøgersen, 1995), with psychological factors such as attitudes, preferences, desires, beliefs, values, and goal-setting playing a crucial role (Michie et al., 2011). Food choices are to a large extent subject to semi-automatic processes embedded in habits (Rejman et al., 2019), which might explain why there is uncertainty and disagreement among scholars as to which of the three conditions (capability, opportunity, or motivation) is most influential in changing consumers' food choices and how important personal factors are.

Translated to the case of "sustainable food consumption", the COM-B framework suggests that personal motivation to act sustainably may be an important driver of behavior change; however, motivation alone is often not enough to make consumers shift to sustainable consumption patterns. Consumers also need to possess (or acquire) the capabilities necessary to perform the desired behavior, including the ability to break with old habits, and be given ample opportunities and easy access to sustainable foods.

3.2.2. Food environments

In the literature on food consumption and healthy diets, the so-called *food environments* play a decisive role as levers for creating conditions that foster behavior change (SAPEA, 2020; HLPE, 2017), i.e., for building capability, creating opportunity, and increasing motivation among consumers. The food environment is "the consumer interface with the food system" (Downs et al., 2020:5; HLPE, 2017) and encompasses different dimensions of "how" and "where" consumers are exposed to different types of foods and practices in their personal daily lives (Herforth and Ahmed, 2015), which Turner et al. (2018) refer to as "the personal domain of the food environment" (p. 95). In essence, sustainable food consumption is influenced by the extent to which individual consumers experience the following conditions (adapted from Turner et al., 2018; HLPE, 2017): physical access to sustainable foods and practices (availability and accessibility); economic access to sustainable foods and practices (affordability); and desirability and attractiveness of sustainable foods and practices.

The personal domain is closely linked to the external domain of the food environment (Turner et al., 2018), which describes the opportunities, constraints, and interventions within a given context in a more general way (see, e.g., HLPE, 2017). We draw on the external domain of the food environment in Section 3.3 on interventions.

3.2.3. Synthesis of enabling conditions

Bringing the two perspectives—individual consumer level (COM-B) and food environments—together, we arrive at a comprehensive list of interrelated enabling conditions for prompting consumers to shift to more sustainable food consumption patterns (see Fig. 2). Three enabling conditions relate to consumers: (1) capability, i.e., awareness, knowledge, and skills related to sustainable foods and practices, (2) motivation to adopt sustainable foods and practices, and (3) opportunity related to sustainable foods and practices. Three enabling conditions relate to the required features of sustainable foods and practices, in relation to competing "conventional" options: (4) attractiveness and desirability, (5) competitive and affordable consumer prices, and (6) availability and accessibility. These six interrelated conditions represent target areas for interventions towards sustainable food consumption, which are the subject of the next section.

3.3. Interventions to trigger positive tipping—putting the consumer perspective at the center

The sustainability transitions literature does not provide an exhaustive list of interventions—neither does the behavior change or food literature—since sustainability interventions always need to be tailored to the specific spatial and temporal context (Lenton et al., 2022; Michie et al., 2011). Also, in this paper, we do not aim for an exhaustive list but rather a typology of interventions that helps decision-makers to choose an effective mix of interventions.

Prominent strands in the behavior change literature focus on public policy interventions (e.g., the behavior change wheel by Michie et al., 2011). Public policy is also the focus of many sustainability transition frameworks on social technological systems (Zeppini et al., 2014). Other authors take a broader approach and organize behavior change interventions by type of actor (public policy, private companies, NGOs, etc.) and level of coercion (ban, regulation, financial (dis)incentives, nudging, etc.) (Lemken et al., 2018). Yet some consumer studies (e.g., Xhelili and Nicolau, 2021) organize interventions according to how an intervention alters the choice options consumers face (e.g., choice expansion, choice editing, choice environment). The tipping point framework by Lenton et al. (2022) is comprehensive and mentions broad categories of interventions by different groups of actors (e.g., "policy intervention and public investment", "private investments and markets") and in different spheres (e.g., "social innovation", "technological innovation", "ecological intervention").

For the transition to sustainable food consumption, we propose drawing on models from the discipline of (social) marketing (Kotler and Keller, 2016) and the above-mentioned food environment concept (HLPE, 2017; Turner et al., 2018), putting the consumer perspective at the center. In this vein, interventions are conceptualized according to the "dimensions" of the consumer experience the intervention is trying to alter. Merging the "4Ps" from the marketing mix model with the food environment concept yields the following four intervention dimensions for sustainable foods and practices (Fig. 2): (1) attractiveness and performance (=Product), (2) financial-monetary aspects (=Price), (3) accessibility and availability (=Place), and (4) information, education, promotion, and nudging (=Promotion).

Two aspects are important to mention when proposing this typology of interventions for sustainability transition frameworks. First, the

(social) marketing literature highlights the notion that consumers do not view the desired behavior in question in isolation but usually in comparison to "competing" options (Kotler and Keller, 2016), which is important to consider when designing interventions for sustainable foods and practices in the four dimensions. Second, this typology offers a consumer-centric view on interventions, potentially heightening our understanding of how single interventions within and across the four dimensions fit into the "bigger picture" of the food environment. The marketing mix model as well as the food environment concept suggest that a coherent mix of interventions across the four dimensions are most effective in inducing behavior change (Kotler and Keller, 2016; HLPE, 2017).

Our case study analysis yields insights not only about promising types of interventions but also about important features of successful interventions, summarized in Fig. 3 and elaborated in Section 4.

3.4. Reinforcing feedback

For a system to change from one state to another, reinforcing feedbacks loops are needed. Reinforcing feedbacks accelerate system change by amplifying small initial changes that subsequently trigger a societal tipping point. While negative feedback loops maintain the current state of the system, positive reinforcing feedback loops, if sufficiently strong, accelerate a system change (Lenton et al., 2022). In interconnected complex systems, reaching a societal tipping point can lead to "upward-scaling tipping cascades". Upward-scaling tipping cascades occur if the activation of a societal tipping point triggers another at a larger scale which, if continued, can lead to rapid societal change (Sharpe and Lenton, 2021).

Inspired by the framework to operationalize tipping points provided by Lenton et al. (2022), we identify five reinforcing feedback mechanisms. (1) Social contagion—peer influence is known to be a major barrier or motive to adopting a more sustainable food consumption behavior (Higgs and Thomas, 2016). The more consumers adopt a sustainable practice, the more pressure to conform to the collective identity is put on the remaining consumers, and the easier it is for consumers to adopt a more sustainable dietary style (Lenton et al., 2022). (2) Collaboration—a large number of studies have investigated the effectiveness of measures and actions to motivate consumers to change their food-related behavior (Kwasny et al., 2022). However, although effective in its area, most measures are context- and discipline-specific. To trigger a societal tipping point, interdisciplinary thinking and collaboration between researchers, NGOs, stakeholders of the food industry (e.g., retailers, processors, farmers), as well as consumers is needed (Kwasny et al., 2022). Moreover, (3) broad policy support is crucial to reduce risks associated with implementing sustainable practices and products. From research on transitions in the mobility and energy sector we know that the implementation of new technologies is associated with high risks for the sector that need to be overcome by policy instruments by creating niches where innovative products may develop (Tziva et al., 2020). To ensure and maintain the effectiveness of measures and policy instruments, (4) monitoring (Onwezen, 2022) and (5) continuous support are crucial to constantly push the system. Lastly, (6) positive cascading effects are needed, e.g., that one big player takes a radical step towards sustainability (pioneer) and others follow the example (market followers). Based on the conceptual work presented here, we arrive at the framework for tipping points in the food sector presented in Fig. 3.

4. Case study analysis

4.1. Methodology

The empirical analysis is based on four case studies from Denmark: (1) increased consumption of organic food, (2) increased consumption of wholegrain food, (3) increased consumption of healthier food options, and (4) reduction of food waste. The case studies were selected based on consultation with experts from the Danish food market, including representatives from food companies, retailers, industry organizations, NGOs, and think tanks. Three discussion rounds took place between spring 2021 and winter 2022, each of which lasted between 20 and 60 min.

The chosen case studies have in common that substantial progress towards sustainable food consumption has already been made and frequently referred to by stakeholders from the food industry or in scientific publications as positive examples. Table 1 provides a short overview of the progress achieved in each case study. The four case studies represent different dimensions of sustainable food consumption; together, they have the potential to contribute to sustainable food consumption, following the definition of the FAO (2016). However, we recognize that none of the individual cases fulfills all dimensions of sustainable food consumption.

The case study analysis was based on a two-step procedure. First, we conducted an extensive literature search for each of the case studies, including not only scientific literature but also project reports, secondary market data, newspaper articles, and press releases. The material was analyzed with an iterative approach of thematic analysis with cross-checks by several analysts. The thematic analysis was based on the conceptual framework presented in Fig. 3, which is organized around enabling conditions, reinforcing feedback, actors, and interventions for triggering a societal tipping point. The literature search and analysis

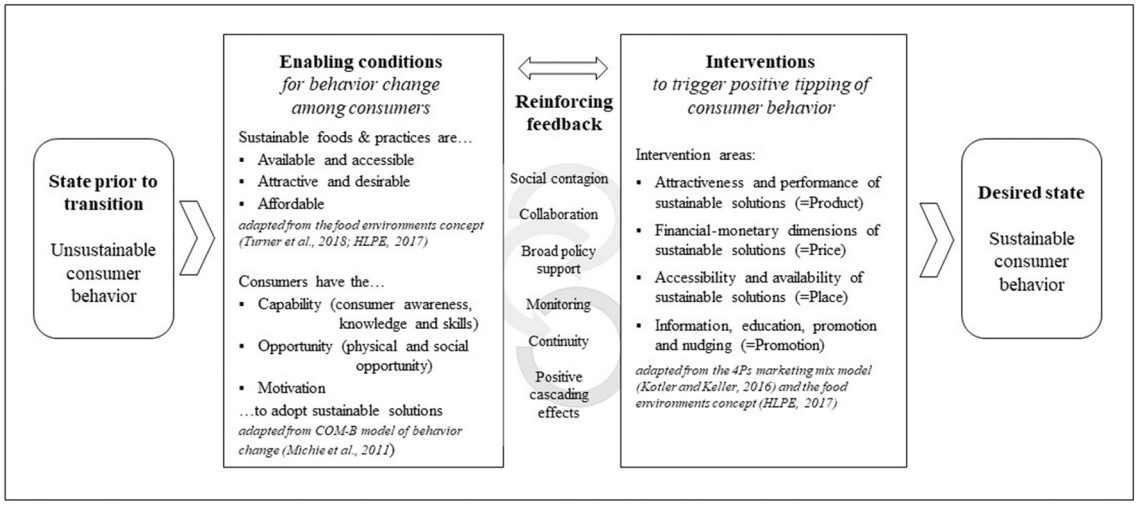

Fig. 3. Framework for moving towards societal tipping points in the transition to sustainable food consumption.

Table 1
Four case studies on sustainable food consumption.

Increased consumption of organic food
Organic food consumption The foundation of the success story of the Danish organic market was laid already in 1987 when Denmark became the first country in the world to introduce governmental standards and principles for organic food and farming (Aschemann et al., 2007). Today, the Danish organic label (Ø label) is well known by Danish consumers (Food Nation, 2019). In 2022, organic food had a market share of 13 %, with an average of 77 % of Danish consumers buying at least one organic product per week, making Denmark the global market leader of all countries. The market share varies a lot among product categories; the category with the highest market share is bananas (80 % organic), followed by carrots (53 % organic) and eggs (44 % organic) (Organic Denmark, 2022).
Increased consumption of wholegrain food The Danish "Whole Grain Partnership" is a multi-stakeholder initiative that targets an increased wholegrain consumption and was founded by representatives from the food industry, health NGOs, and public authorities in 2008 (Fuldkornpartnerskabet, 2021). From 2000–2004 to 2011–2013, the consumption of wholegrain increased by 75 %. In addition, the number of wholegrain products carrying the label increased from 150 in 2009 to 800 in 2018 (SAPEA, 2020). In 2015, 68 % of Danis consumers stated to be aware of the associated "Wholegrain Partnership Label" and 54 % stated to shop products labelled with the logo (Fuldkornpartnerskabet, 2015).
Increased consumption of healthier food options The increased consumer awareness of healthier food options is closely linked to the introduction of the "keyhole label", which was developed to help consumers make healthier food choices by eating less (and healthier types of) fat, less sugar, less salt, and more dietary fiber and wholegrains. Denmark introduced the label in 2009 (Nordic Council of Ministers, 2010). Already in 2012, 93 % of consumers knew about the label. In 2021, 58 % of consumers stated that the keyhole label influenced their food choices (Laasholdt et al., 2021a) and in 2023, the keyhole label could be found on more than 4000 products.
Reduction of food waste Efforts to reduce food waste in Denmark were initially triggered by pressure from civic society (namely the NGO "Stop Spild af Mad") (Kulikovskaja and Aschemann-Witzel, 2017). Early engagement from food retailers, and later on also policy support, led to a reduction of food waste of 25 % between 2010 and 2015, which helped Denmark reach a European record in food waste reduction after starting with food loss figures higher than EU averages (Klitkou et al., 2019). Most consumers are aware of the problem, and 85 % stated to have heard or seen information about food waste (Stancu and Lähteenmäki, 2018).

took place between autumn 2021 and spring 2022.

Second, the findings from the desk research were fact-checked by two qualitative in-depth interviews with informants from the Danish food sector, followed by three discussion rounds with experts Participants of the discussion rounds were stakeholders from the private food industry (food producers, food retailers), representatives of industry associations, NGOs, and think-tanks, and scientists within the field of food consumption and food system transitions. The interviews discussion rounds served as a means to ensure the accuracy of the research findings and conclusions. The feedback was documented in written protocols, but the interviews and discussion rounds were not recorded nor transcribed. Based on the expert feedback, small adjustments in terminology were made, and the findings were complemented with insights from additional sources of information named by the informants. The interviews and discussion rounds were conducted physical and online between January and August 2022.

4.2. Findings

This chapter starts off with a reflection on the progress achieved in each of the four case studies in terms of moving consumer behavior towards and beyond a tipping point. The remainder of the chapter is organized according to the main components of the conceptual framework presented in Fig. 3 in order to understand how the progress observed in the case studies came into place.

4.2.1. Progress towards societal tipping points in the four case studies

A system transition is based on several tipping points at different levels of consumer behavior, ranging from changes in psychographic determinants (e.g. awareness, knowledge, motivation) to changes in actual behavior. Hence, we analyzed the progress achieved in each of the case studies not only in terms of changes in consumers' eating and purchasing patterns but also in terms of changes in psychographic determinants.

We found that the level of progress differs substantially among the four case studies, and a tipping of actual consumer behavior has only been reached in two case studies, namely regarding the consumption of wholegrain foods and the consumption of organic foods in selected product categories. Already in 2015, the majority of Danish consumers (68 %) stated to be aware of the associated "Wholegrain Partnership Label". A cross-sectional study revealed that between 2015 and 2019, 54 % of Danes consumed the amount of whole grain recommended in Denmark (Andersen et al., 2021). Similarly, awareness of the Danish organic label is high among Danish consumers (already in 2004, 96 % of Danish consumers stated to at least have heard of the Ø label). However, the market share varies a lot among product categories (Organic Denmark, 2022) indicating a gap between consumers' awareness and actual behavior.

The impact of the keyhole label on actual dietary patterns is somewhat difficult to determine since data on market shares of products with and without the keyhole label is not publicly available. The keyhole label has nevertheless been successful in enabling consumers to identify the healthy options on the supermarket shelves, due to its high levels of recognition and consumer trust. Awareness of food waste reduction is high among Danes. As such, 85 % of consumers stated to have heard or seen information about food waste (Stancu and Lähteenmäki, 2018). In contrast, results from polls highlighted that 84 % of Danish families (with kids under 18) admit buying at least sometimes more food than needed and 73 % stated to intentionally prepare more food than needed (Laasholdt et al., 2021a,b). Following data provided by the European Environment Agency (2023), the actual amount of food waste from Danish households has decreased around 8 % between 2011 and 2017.

4.2.2. Enabling conditions, interventions and reinforcing feedback

The following sections describe enabling conditions, interventions, and reinforcing feedback, observed in the four case studies.

4.2.2.1. Enabling conditions. The case study analysis showed that the following six conditions are essential for moving towards a societal tipping point in the transition to sustainable food consumption (Table 2).

4.2.2.2. Attractiveness and desirability. The case studies show how sustainable products can be successful on the market if they are attractive in terms of visual appearance, smell, taste, and texture. High attractiveness reduces the perceived sacrifice of switching to a sustainable option. The lower the perceived sacrifice, the easier it is for consumers to change their behavior and choose the sustainable option (Hoek et al., 2017). For instance, organic food companies in Denmark are successful in positioning their products as high-quality and tasty products, both in the premium as well as in the middle price segment. The same applies to the collaborating partners of the Whole Grain Partnership. Their strategy is to foster the development of new wholegrain products. The increased consumption of wholegrain foods indicates that consumers are satisfied with the range of wholegrain products on the market (Lourenço et al., 2019).

Table 2
Enabling conditions for behavior change among consumers.

Enabling conditions	Description
Food supply level	
Attractiveness and desirability	Sustainable foods are characterized by high quality. They are attractive and desirable in terms of visual appearance, smell, taste, and texture to reduce perceived sacrifices of sustainable behavior change.
Competitive and affordable consumer prices	Sustainable foods are affordable and offered at a competitive price.
Availability and accessibility	A variety of sustainable foods is widely available in supermarkets, public kitchens, restaurants, and delivery services, and sustainable foods are highly salient and prominently placed.
Consumer level	
Capability	Awareness, knowledge, and skills: Consumers are informed about sustainable alternatives and know how to make sustainable choices; they are capable of preparing sustainable foods.
Motivation	Consumers are motivated to adopt sustainable foods and practices.
Opportunity	Sustainable foods and practices are an integral part of the food culture and society.

4.2.2.3. Competitive and affordable consumer prices. Competitive and affordable consumer prices facilitated the uptake of sustainable foods among consumers in Denmark in the consumption areas analyzed in the case studies. Products from (more) sustainable production systems, e.g., organic foods, are often associated with higher production costs and consumer prices, which is a major barrier for consumers to purchase organic food (Aschemann-Witzel and Zielke, 2017). Danish retailers, however, have been successful in positioning organic foods as affordable in consumers' views, and there is a strong focus on competitive prices for organic food between the chains.

Regarding price, the consumption areas analyzed in the other case studies are of somewhat different nature than the case of organic food consumption. Wholegrain foods and products with the keyhole label are not per se more expensive than other options. All supermarket chains, e.g., offer wholegrain rye bread at low prices. Endeavors to reduce food waste are often even associated with saving money, e.g., when supermarkets offer large price discounts on products close to the expiry date.

4.2.2.4. Availability and accessibility. The case studies suggest that the transition towards sustainable food consumption gains momentum as soon as there is a variety of sustainable alternatives widely available in supermarkets as well as in out-of-home consumption, such as public kitchens and restaurants. For instance, supermarkets and discount stores in Denmark started to offer a wide range of organic foods already in the 1990s. Nowadays, the product range spans from organic premium products to "basic" products at low prices. The Danish organic movement is also known for successfully introducing and establishing organic foods in public kitchens and restaurants. In 2009, the governmental Organic Cuisine Label was introduced, which shows customers of restaurants, canteens, and public kitchens the total share of organic raw ingredients and beverages with a bronze, silver, or gold classification. Most Danish consumers (58 %) recognize the label (Food Nation, 2021).

Retailers, together with food companies, were also crucial players in the Whole Grain Partnership and the keyhole label initiative, in that they quickly started to widely offer respective products and promote the two labels. Another example is the initiative by a large Danish supermarket chain that stopped the promotion of "buy 3 for 2" in 2008 to reduce food waste (Halloran et al., 2014).

4.2.2.5. Capability. Consumer awareness, knowledge and skills were identified as highly relevant to drive the sustainable transition of food consumption patterns. Consumers in Denmark are very familiar with organic food and farming and know how to identify certified organic food. The organic label is the best-known labeling system in Denmark (Organic Denmark, 2021). The keyhole label was already recognized by the great majority (96 %) of consumers in 2014, and 58 % state that the keyhole label influences their food choices (Laasholdt et al., 2021a,b). The picture looks similar for food waste reduction. In a study from 2018, the majority of Danish consumers (85 %) stated to have recently come across information about food waste avoidance (Stancu and Lähteenmäki, 2018).

4.2.2.6. Motivation. The case study materials do not provide detailed insights into consumer motivation. Nevertheless, the available survey data suggests that consumers in Denmark are generally positive about the four behaviors in question, and the data on sales and consumption supports the notion that many consumers are motivated (Lourenço et al., 2019; Aschemann-Witzel and Zielke, 2017).

4.2.2.7. Opportunity. The four case studies are positive examples of how sustainable behaviors can become widely accepted, i.e., how social and cultural norms can change, and how this change facilitates behavior change at the individual level. For instance, it is the norm that daycare institutions serve wholegrain bread to toddlers, and parents of schoolchildren are advised to put wholegrain bread sandwiches into the meal boxes.

4.2.3. Interventions

The case studies indicate that tipping points in the transition to sustainable food consumption are not triggered by single interventions; rather, an interplay of multiple interventions in all the four dimensions of the food environment creates the conditions discussed above that drive a successful transition (see Table 3).

4.2.3.1. Promotion. Sustainability attributes need to be communicated clearly so that consumers can make an informed decision. As shown in three of the case studies analyzed, the introduction of third-party labels is one option to effectively communicate the product attributes to consumers. In 1990, Denmark was the first country in the world to introduce a governmental label for organic food. The so-called Ø label, which is still in place, guarantees consumers that farmers and food companies are certified and comply with the governmental standards for organic

Table 3
Interventions to trigger positive tipping.

Food environments as areas of action	Description
Information, education, promotion, and nudging (=Promotion)	Clearly defined terminology with common labels and standards Point-of-sale promotion and nudging Communication of multiple benefits Campaigns and public events Education and training
Attractiveness and performance (=Product)	Development of tasty and attractive food products and meals
Accessibility and availability (=Place)	Introduction of sustainable foods and practices in outlets where "mainstream" consumers usually shop Development of distribution channels for dedicated consumers
Financial-monetary aspects (=Price)	Pricing instruments

production (Padel et al., 1999). The keyhole label was initially launched in Sweden in 1989 (The Swedish Food Agency, 2021), and Denmark introduced the label in 2009. The Whole Grain Partnership organization also decided to introduce a common label in 2008 to make it easier for consumers to recognize wholegrain products and to facilitate monitoring of market success (Greve and Nees, 2014).

Food shopping behavior is highly habitualized and difficult to change. High salience and prominent placement of sustainable foods is important for "nudging" consumers into choosing sustainable alternatives, with point-of-sale promotion as another important measure. To promote products with the keyhole label, the large food retailers supported national campaigns initiated by the Ministry of Food, Agriculture and Fisheries, e.g., with ceiling signs, posters, flyers, shelf labels, and promotional videos in the fruit and vegetable as well as fish sections. In addition, informational material, such as recipes, and competitions with prizes were offered in the stores to target consumers while shopping (Mørk et al., 2017). The case study on food waste provides similar examples of retailers taking action by placing suboptimal food side by side with regular food. Some retailers even introduced specific price tags that include information about food waste or implemented other food waste-related communication at the point of sale (Kulikovskaja and Aschemann-Witzel, 2017).

The case studies show that personalized and emotional campaigns are promising to accelerate the consumer transition, especially to reach consumers with a low interest in sustainability (Guthrie et al., 2015). The Whole Grain Partnership has run several national campaigns, e.g., the initiative "Vil du have det hele med?" specifically targeting young women to increase their wholegrain intake (Greve and Nees, 2014). In addition, the National Whole Grain Day was introduced to raise awareness of the importance of sufficient wholegrain intake (Lourenço et al., 2019). The keyhole label is also supported by annual national campaigns by the Ministry of Food, Agriculture and Fisheries.

The case studies on organic food and food waste reduction further show how promotion campaigns can raise consumer awareness for the multiple benefits of sustainable behavior. The organic sector has been successful in communicating the multiple benefits of organic food (Aschemann-Witzel and Niebuhr Aagaard, 2014) many consumers perceive organic food as beneficial in terms of the environment, human health, and animal welfare. Reducing food waste not only has environmental benefits but also personal benefits (i.e., saving costs). Highlighting additional benefits, apart from environmental benefits, makes sustainable behavior change more attractive.

The analyzed case studies show that educational programs in schools seem to be a promising component of the overall strategy (Evans et al., 2012). Especially the organic movement has been supported by several measures aiming to increase knowledge and skills about organic food among different target groups. For example, educational materials have been developed for schools. Moreover, education and training of kitchen staff has been a crucial component in supporting public kitchens in introducing organic foods and changing the mindset of kitchen staff (Daugbjerg, 2021).

4.2.3.2. Product. For most consumers, taste is the most decisive food quality attribute (Hoek et al., 2017), and expected bad taste leads to avoidance of sustainable alternatives (Clark and Bogdan, 2019). It is therefore crucial to develop tasty and attractive sustainable foods and meals. In the early days, organic food tended to have deficiencies regarding the limited durability and suboptimal appearance, and the selection was very restricted (Hughner et al., 2007). These barriers have been overcome in Denmark, and organic companies can now successfully position their products as high-quality and tasty products. The organic product range has grown, facilitated by governmental support for innovative organic products. As such, the Danish government has supported supply chain collaborations on product development and provided help for small companies to develop new products (Holmbeck, 2020).

4.2.3.3. Place and distribution. The case studies illustrate the crucial role of "availability" and "accessibility" for the uptake of sustainable foods. Offering sustainable solutions in places where mainstream consumers usually shop is a key lever for accelerating the consumer transition. For instance, in 1993, the largest Danish retailer began to offer organic food in its "normal" supermarkets on a large scale. This was a game changer for the development of the organic sector in Denmark. Other retailers followed soon thereafter. From that point on, organic food was widely available and easily accessible to consumers.

Food retailers link producers and consumers and act as gatekeepers in the supply chain, which makes them key players for the transition to sustainable food consumption. Large retail chains were also important partners in the keyhole initiative, the Whole Grain Partnership, and the food waste movement. With their decisions to market sustainable products, the big retail chains have made "alternative" products accessible to the mass market and thus had a huge impact on driving the market of sustainable food products (Greve and Nees, 2014; Nordic Council of Ministers, 2010).

Moreover, it is important to develop specialized distribution channels for consumers already dedicated to sustainable food consumption. One approach are box-scheme delivery systems that offer dedicated consumers the opportunity to get a wide range of sustainable foods delivered to their house, such as the large Danish organic box-scheme company "Aarstiderne" founded in 1999 (Thøgersen, 2002). Another example is the Danish box-scheme company "Eat Grim", founded in 2018, that supplies interested consumers with vegetables that do not fit the norm and would otherwise be wasted. The box-scheme approach removes some important barriers, such as saving time to find sustainable products in supermarkets or reducing the cognitive burden to choose between sustainable and "conventional" products.

4.2.3.4. Pricing. Due to higher production costs, in most cases, sustainable food products are associated with higher consumer prices. As higher prices are a major barrier for consumers to make sustainable food choices (Aschemann-Witzel and Zielke, 2017), appropriate pricing instruments are needed. For the organic sector in Denmark, food retailers are key actors. Over the years, the organic product range has diversified, not only in terms of product variety but also in terms of price positioning. For instance, a major supermarket chain initiated a price differentiation strategy where it, in addition to the existing organic product line, introduced a new range of "everyday" organic products at lower prices. Organic products are also prominent in discount chains in Denmark with fierce price competition; one discounter, e.g., promotes itself as "the cheapest place to buy organic", based on an independent annual price check by a major Danish newspaper (Netto, 2023).

Food retailers also implemented several price-related actions to avoid food waste. For instance, a common practice in food retailing is to offer suboptimal food items at lower prices. To increase awareness of such offers, the products carry special price tags. In addition, retailers often offer price reductions for products close to the expiry date. Price reductions vary in formats: Some retailers use fixed-price reduction levels, while others use percentage reductions (Kulikovskaja and Aschemann-Witzel, 2017).

In the context of pricing, it is important to mention the supply-side policy measures that are in place. Certified organic farmers in Denmark have been receiving subsidies since 1994. In addition, farmers converting from conventional to organic farming receive financial support (Aschemann et al., 2007; Lov no. 363, 1987).

4.2.4. Reinforcing feedback

Reinforcing positive feedback can amplify a small initial change and is thus an important catalyst for system transformation (see Table 4 for an overview of reinforcing feedbacks for a sustainable transition of the

Table 4
Reinforcing feedbacks.

Reinforcing feedback	Description
Social contagion	Mere exposure effects and social norm effects
Collaboration	Networks between actors to enhance learning processes and increase individual impact
Broad policy approach	Support from many policy areas and levels
Monitoring	Monitoring and accountability to level up the success
Continuity	Continuous support by all actors involved
Positive cascading effects	One big player takes a radical step towards sustainability (pioneer), and others follow the example (market followers)

food sector).

Peer influence is known to be a major barrier or motive to adopting a more sustainable food consumption behavior (Higgs and Thomas, 2016). The more consumers adopt a sustainable practice, the more pressure to conform to the collective identity is put on the remaining consumers (Lenton et al., 2022). For instance, the more the Organic Cuisine Label was recognized by consumers, the more it became normal to have organic meals when eating out (Food Nation, 2021). Another important amplifier derived from the case analysis was collaboration. Collaborative initiatives are often very impactful. For instance, collaborative actions have been the centerpiece of the organic movement in Denmark since the beginning. Since 1980, policy-makers have followed a collaborative approach that integrated conventional and organic interest associations. In addition, the foundation of the umbrella organization "Organic Denmark" enabled collaboration among all groups of relevant actors (Organic Denmark, 2021). The keyhole initiative has always benefited from the joint initiative of the four Nordic countries. The cooperation had synergy effects in terms of the communication strategy and legislation (Nordic Council of Ministers, 2010). The introduction of a broad policy approach and the support from many policy areas were also promising to amplify a societal tipping point. For instance, although there is currently no national plan on food waste reduction, the subject is included in national strategies. As such, the aim to reduce food waste was included in the resource strategy published by the Danish government in 2013. More recently, the action plan for circular economy includes initiatives to tackle food waste reduction (Ministry of Environment and Food, 2017). Also, the principles of organic farming were integrated into a diverse range of policy areas, such as national strategies for nature restoration, green economic growth, and plans to protect drinking water and reducing pesticide residues in food (Holmbeck, 2020). Monitoring and accountability are important to level up the success. For instance, the success of the Wholegrain partnership has been monitored since the beginning. Data on sales of products carrying the wholegrain label was regularly assessed and, if necessary, the partners' communication strategy was adapted (Greve and Nees, 2014). Lastly, continuous support is needed to trigger a societal tipping point. Since the beginning, policy-makers in Denmark have followed a collaborative policy approach that integrated conventional and organic interest associations. They have thus built a consensus along the food supply chain that organic farming is an integral part of the Danish food sector. Due to policy support across legislative periods, stakeholders along the supply chain have experienced continuous assistance and stability—another driver of the organic transition—already in the early years (Schvartzman, 2008).

5. Discussion and conclusion

This study aims to close a research gap by identifying factors that can trigger societal tipping points in transitions to sustainable food consumption. We developed a conceptual framework for the transition to sustainable food consumption based on the framework to operationalize tipping points by Lenton et al. (2022) and existing models of behavior change, food consumption, and social marketing (COM-B model, food environments concept, "4Ps" marketing mix model). The development of the conceptual framework was informed by an analysis of four case studies of sustainable food consumption from Denmark.

Sustainability transitions in the food sector can have different starting points (Geels et al., 2016), as seen in the case studies from Denmark. The increased interest in food waste reduction was triggered by engaged citizens voicing a desire for change. The upscaling of the Danish organic movement, in contrast, can mainly be attributed to the introduction of national policies laying down governmental standards for organic food and farming. The Whole Grain Partnership, founded by representatives from health NGOs, public authorities, and the food industry, is an example of a collaborative initiative.

The four case studies support the notion that—regardless of "how" and "where" the transition starts—the enabling conditions identified based on the COM-B model (Michie et al., 2011) and the food environment concept (HLPE, 2017) can, in combination, lead to lasting changes in consumer behavior, and trigger a positive societal tipping point in the transition to sustainable food consumption. Based on the case studies analyzed, large-scale tipping points in consumer behavior have admittedly only happened at a small scope. In selected product categories – i.e. bread and breakfast cereals (wholegrain intake), and bananas, carrots and eggs (organic food consumption) – tipping points have been reached, in that consumption levels increased substantially across large parts of the population, and have remained at a high level, without any further additional interventions. These examples suggest that favorable conditions can boost consumer demand and lead to tipping points in single product categories. However, it also needs to be acknowledged that the concept of positive tipping in the transition to sustainable food consumption remains somewhat at the speculative level. The transition should not be viewed as a single pathway with a single tipping point. Rather, the transition represents a complex multi-dimensional challenge requiring consumers to change their food-related behaviors in many different ways; hence it involves a variety of pathways and tipping points in different dimensions.

The present paper illustrates the benefits of bringing different strands of "sustainability" discourses together, which have evolved in parallel in separate academic communities; in this case, the sustainability transition discourse with a systems-view on the one hand and the social-ecological discourse of sustainable food consumption with a focus on the individual consumer on the other hand. It would be useful, for mutual benefit, for the sustainability transitions literature to increasingly harness insights on behavioral drivers of decision-making from respective theoretical models and empirical studies (tailored to specific groups of actors, e.g., consumers, industry, retailers, policy-makers, NGOs); vice versa, behavior change discourses would benefit from a stronger recognition of the embedment in larger societal transitions.

Sustainability transitions are wicked problems that require a holistic mix of interventions. The case studies show that organizing interventions according to a consumer-centric view based on the "4 Ps" of the marketing mix (product, price, place, promotion) and the four dimensions of the external food environment is a promising taxonomy for identifying a successful mix of consumer-oriented interventions.

Another important finding from the case studies relates to "how" consumer-oriented interventions have been implemented to create enabling conditions for societal tipping among consumers. As expected, the transition to sustainable consumption resulted from an interplay of many interventions by many different actors. A striking element of the case studies from Denmark is the collaborative nature of how actions by different groups of actors were coordinated, often creating an impactful mix of interventions. The case studies underline how reaching the tipping point in the transition to sustainable food consumption requires engagement from all groups of actors: business/industry, policy, civil society, and consumers (Aschemann-Witzel et al., 2023; Bauer et al., 2022). Different actors have different capabilities, motivations, and opportunities (Köhler et al., 2019). Aligning the available resources

around the "4 Ps" seems crucial to change consumer behavior at a large scale. This can be done by initiating strong formalized networks that involve all groups of actors (companies, retailers, government agencies, NGOs) and thereby foster vertical and horizontal cooperation.

In this context, it is important to highlight that the level of policy commitment largely determined the speed of the transition to sustainable food consumption in the case studies analyzed, i.e., whether positive developments in niche segments scaled up or not. Sustainability is a public good, which is why sustainability transitions struggle with free-rider problems. Private actors, such as farmers, food retailers or consumers, only have limited incentives to foster sustainable behavior change. Therefore, policy support is crucial (Köhler et al., 2019).

However, not only policy-makers but also industry actors can have a crucial impact, especially when triggering upward-scaling tipping cascades in the whole sector. Large retail chains play a decisive role in scaling up systemic change (Bauer et al., 2022). They determine the degree to which sustainable food is widely available and how it is promoted at the point of sale (Esbjerg et al., 2022). The case studies demonstrate that the transition is likely to gain momentum as soon as large retailers are on board. A radical new step towards sustainability by a large retail chain will likely cause positive cascading effects, since competitors will follow and other key actors will implement complementary actions, as already demonstrated in previous studies (Schulze et al., 2019).

The case studies highlight how consumer behavior is embedded in and dependent on actions by other players in the food system. The external conditions and food environments affecting consumers' food choices are largely in the hands of private actors from the food industry (SAPEA, 2020), raising the question as to which conditions would trigger these players to implement respective actions in favor of sustainable food consumption. Answering this question exceeds the scope of the current paper, but the case studies confirm that consumers can play a pivotal role if they do not act as "passive" consumers but as sovereign stakeholders who "vote with their money" (Ehgartner, 2018). The framework developed in this paper should be complemented with similar frameworks for other key players in the food system in order to identify how the lock-in problems (Kuokkanen et al., 2017) can be overcome. Taking different perspectives into account (e.g., system thinking) rather than only focusing on specific academic and politic disciplines (e.g., silo thinking) are crucial for the sustainability transition of the food system (Reisch, 2021). More specifically, the potential of integrating knowledge from behavior change models into a broader sustainability framework as well as policy actions, has only recently been recognized. Implementing insights from behavioral frameworks, can improve existing theoretical frameworks and policies, by adding knowledge that has been neglected, so far (Just and Gabrielyan, 2016). Empirical evidence on how consumers react to different interventions will increase the likelihood of choosing an effective mix of interventions and add a variety of potential interventions that might have been neglected so far (Reisch, 2021). The theoretical framework developed in this study provides evidence for the above-mentioned benefits of implementing behavioral insights into sustainable transition models. As such, the framework combines knowledge from the sustainable transition literature with insights from research and theories on consumer behavior and enables researchers and policy makers to derive effective interventions as well as a proper understanding of system dynamics and processes.

Our case studies revealed that it is important to diversify sustainable solutions for different consumer segments, reflecting the findings from previous consumer research according to which distinct consumer segments differ in their sociodemographic characteristics as well as their food consumption motives (Jürkenbeck et al., 2021). A diverse sustainable product range accompanied by communication measures tailored at different consumer segments (e.g., addressing diverse benefits of sustainable food consumption such as climate and environmental impacts, personal health, convenience, and/or price) allows reaching a critical mass of consumers.

The selection of the four case studies analyzed in this paper can—and should—be seen critically. First, the case studies examine selected aspects of sustainable food consumption, not food consumption overall. Denmark is among the countries with high per capita consumption of animal foods (FAO, 2023).

Second, the final stage of the sustainability transition has not been reached in the consumption areas of the four case studies. It remains to be seen whether and when the "late majority" of consumers (let alone the laggards) will join, i.e., whether large-scale societal tipping will occur in the near future. For example, large-scale changes at the psychographic level with positive attitudes and high recognition of the keyhole label are not enough to drive change towards healthy diets. Unfortunately, the adoption of sustainable food consumption has little resemblance with technology transitions, such as the transition from mobile phones to smartphones, where the "new" option provides many benefits so that it pushes the old technology out of the market. Sustainable food consumption is, overall, for many consumers associated with sacrifices rather than benefits (Grunert, 2011). Following a sustainable diet means to make compromises, changing habits and being aware of the consequences of the food choices we make.

However, reaching a more sustainable food system requires moving away from a binary perspective, such as defining a successful transition as moving towards 100 % organic food consumption, diets without meat and animal products, or no food being wasted (Crowder and Illan, 2021). For instance, organic farming outperforms conventional farming in terms of biodiversity, soil quality, and pesticide use, but it oftentimes produces lower yields and thus, reinforces the competition for limited land resources (Pickett, 2013; Crowder and Illan, 2021). Thus, a sustainable food system is likely based on a combination of different approaches (e.g., organic farming and other farming systems; vegetarian diets and diets with small amounts of animal products, etc.), and thus the result of a mix of societal tipping points on various dimensions and systems.

Against this background, the case studies provide success stories of how positive tipping has occurred, admittedly only in selected product categories but among large consumer segments, so that certain sustainable foods and practices have left the niche and reached the "early majority". The diffusion of innovation theory supports the notion that different types of interventions are needed to gain new customers over time (Kotler and Keller, 2016). The interesting question is thus whether the transition will continue without substantial additional interventions, or whether the late majority can only be reached with other (more disruptive) measures.

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Declaration regarding generative AI

We hereby confirm that we have not used generative AI in the entire process, neither for writing this manuscript nor for generating and analysing data.

CRediT authorship contribution statement

M. Schulze: Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **M. Janssen:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **J. Aschemann-Witzel:** Funding acquisition, Writing – review & editing.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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