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Citizens as an innovation source in sustainability transitions – linking the directionality of innovations with the locus of the problem in transformative innovation policy

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Abstract

This article argues that citizens play a key role in sustainability transitions: Citizens have unique knowledge on why social problems occur and experiment with possible solutions to these problems. Yet transformative innovation policy – a policy frame that promotes socio-technical systems change – is guided by a producer-centric innovation paradigm, which focuses on technological breakthroughs rather than social changes driven by citizens. By drawing on multiple research fields, and by using the example of household food waste, this article challenges this paradigm and asserts that addressing sustainability challenges requires a policy frame that defines citizens as an innovation source.

KEYWORDS Transformative innovation policy; consumer innovation; sustainability transition; policy analysis; household food waste

Introduction

In September 2015, the United Nations (2015, 5) published the 2030 Agenda including 17 Sustainable Development Goals (SDGs) to ‘stimulate action over the next 15 years in areas of critical importance for humanity and the planet’. Each SDG links to urgent sustainability challenges including poverty, hunger, health, education, equality, and climate change among others. These challenges can be compared to ‘wicked problems’ because they are highly complex, systemic, and interconnected in nature (Head 2019), and require solution pathways that involves and seeks contributions from many different actors (Crosby, T Hart, and Torfing 2017). To illustrate their wicked nature, the food waste problem (SDG 12.3) has multiple sources and effects: If food waste were a country it would be the third largest greenhouse gas emitter after China and the United States (Heller 2019). Moreover, the edible food discarded every year could feed 3 billion people. Thus, food waste not only carries an environmental, specifically climate, cost, but indirectly also aggravates food insecurity, which afflicts at least 805 million people (FAO 2013; European Commission 2017).

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What is the role of citizens in tackling complex sustainability challenges, such as food waste? In the public management literature, the importance of citizen participation is clearly recognized (e.g. Bovaird and Loeffler 2012; Loeffler and Bovaird 2016; Osborne et al. 2015; Nabatchi, Sancino, and Sicilia 2017; Trischler, Dietrich, and Rundle-Thiele 2019). Citizens, defined as members of a geographic and political community, can contribute to outcomes that have both, personal and social benefits (Nabatchi, Sancino, and Sicilia 2017). However, many of these studies take a dyadic stance with focus on the involvement of citizens in processes managed by professionals or a focal organization (Osborne, Nasi, and Powell 2021), also so-called state actors (Nabatchi, Sancino, and Sicilia 2017). For example, co-production, even in its broad conceptualization (i.e. including commissioning, design, delivery, and assessment), relies on a public sector organization to take the initiative of involving citizens (Nabatchi, Sancino, and Sicilia 2017; van Eijk 2018; Vanleene, Voets, and Verschuere 2020). Considering the complexity of sustainability challenges (e.g. Head 2008), and the fact that sustainability transitions require the transformation of socio-technical systems (Geels and Schot 2007; Markard, Raven, and Truffer 2012), we question whether such an organization-led innovation process is sufficient. As an alternative, we assert that citizens should be defined as an independent innovation source; that is, a driving actor who develops innovations either individually or collaboratively within their social system.

Specifically, in this article we illustrate, both conceptually and practically, *why* sustainability transitions and related policies need to include citizens as an innovation source. First, tackling complex sustainability challenges requires numerous actors, *including* citizens, working together on a variety of solution pathways (Kuhlmann and Rip 2018; Schot and Steinmueller 2018). By using the example of household food waste, and by drawing on practice theory, literature on wicked problems, and consumer innovation research, we propose that the inclusion of citizens is essential when the underlying problem is situated within their everyday life: Citizens are close to the problem (e.g. sources of household food waste) and experiment with different ways to address it (e.g. new practices of buying, storing, handling food). These bottom-up social experimentations form an important element of changing socio-technical systems towards more sustainable modes of production and consumption because they help to challenge and break long-established social norms, practices and lifestyles (Schot and Steinmueller 2018).

Second, studies (including our own) show that the underlying innovation policy design has a substantial impact on whether socially valuable innovations by citizens diffuse or not (Gambardella, Raasch, and von Hippel 2016; Nielsen, Reisch, and Thøgersen 2016; Svensson and Hartmann 2018; Bradonjic, Franke, and Lüthje 2019). We draw on developments in transformative innovation policy (TIP) – a policy frame that promotes innovation activities among actors in a social system towards addressing sustainability challenges – to examine the role of citizens in sustainability transitions. We find that while there are first efforts to conceptually include citizens into TIP (Diercks, Larsen, and Steward 2019), its practice is (still) guided by a producer-centric innovation paradigm which defines organizations as ‘producers’ and citizens as ‘adopters’ of innovations (Bradonjic, Franke, and Lüthje 2019; Nielsen 2021). We again use the food waste example to show possible consequences of such a producer-centric focus: While significant resources are committed to reduce food loss in food production and supply, the waste problem on the household level remains largely neglected.

The article concludes with discussing how TIP needs to be further developed so that it successfully includes citizens as a source of innovation, especially in regards to innovations that address problems linked to unsustainable practices. In so doing, the article contributes to the research priority of designing sustainable ecosystems, including the research question of ‘How can citizens’ creativity, including their problem-solving skills and willingness to participate in addressing sustainability challenges, be harnessed by policy-makers and firms?’ (Ostrom et al. 2021, 346). More broadly, the article contributes to recent efforts in the fields of transformative innovation policy (Schot and Steinmueller 2018; Diercks, Larsen, and Steward 2019), sustainability transitions (Köhler et al. 2019), consumer innovation (de Jong et al. 2021), and public management (Osborne, Nasi, and Powell 2021), all working towards giving citizens a more active role in transformative change.

Being stuck in unsustainable practices – The case of household food waste

To reduce the environmental and social effects linked to food waste, SDG 12.3 calls governments to ‘halve per capita global food waste at the retail and consumer levels’ (United Nations 2015, 27). While this goal concerns the reduction of food waste throughout the entire food production and supply chain, the main contribution needs to come from households because here the largest amount of waste occurs: both in developed and developing countries more than 60% food gets wasted once the food reaches the consumer (United Nations Environment Programme 2021). The painful irony is that one in nine people worldwide is chronically undernourished and with current trends in population and economic growth, a 60% increase in the global demand for food is expected by 2050 (Alexandratos and Bruinsma 2012; FAO, IFAD and WFP 2014). At first glance, it seems surprising that households end up wasting so much food they have bought for consumption. From an individual consumer perspective, wasting food means good money and time is spent on purchasing, storing and preparing food only to throw it away. In addition, consumers feel guilt and other negative emotions including disgust, frustration, annoyance, and anxiety (Graham-Rowe, Jessop, and Sparks 2014; Waitt and Phillips 2016).

However, household food waste cannot be framed as a problem of individuals alone, ignoring the complex interplay between various activities, actors, materials, and spatial-temporal elements (Evans 2014; van Geffen, van Herpen, and Sijtsema 2020). We draw on two literature strands to better understand this complexity. The first is literature on wicked problems; i.e. problems that are highly complex, unstructured, intractable, open-ended, and unpredictable in nature, and to which there is no definitive solution available (Alford and Head 2017; Head 2019). While it is beyond the scope of this study to situate the food waste problem against the ten characteristics originally defined by Rittel and Webber (1973), we highlight one aspect that is of particular relevance for the present study: Problem-related knowledge (e.g. knowledge about why food gets wasted in households) is fragmented within the social system and held by numerous actors with often different interests (Weber and Khademan 2008; Alford and Head 2017; Head 2019). Gaining access to this knowledge is critical for effective solution developments (von Hippel 1994). To achieve this, studies suggest a broad policy approach that involves multiple stakeholders, facilitates the transfer and integration of knowledge across their network, and builds long-term collaborative problem-solving capacity among

them (Weber and Khademian 2008). In fact, literature on wicked problems has from its very beginning critiqued science-based policy approaches as too narrow for addressing societal problems (Rittel and Webber 1973; Head 2019).

The second literature strand is practice theory. A practice is ‘a temporally evolving, open-ended set of doings and sayings linked by practical understandings, rules, teleo-affective structures, and general understandings’ (Schatzki 2002, 87). Practices are a social phenomenon meaning that observable consumer behaviours are not a simple representation of individual values and attitudes, but linked to an assemblage of cultural meanings, socially learnt skills and common tools, technologies and products (Spurling et al. 2013). For example, everyday activities around planning, shopping, storing, cooking, and eating food are deeply entangled in the routines of consumers’ lives, as well as influenced by social, economic, and cultural factors (Quested et al. 2013; Williams et al. 2020). Considering the complexity that underpins practices it comes with little surprise that traditional, rather rationalistic and disembodied government interventions, such as information campaigns to create awareness or guidelines on food waste reduction, only have a limited effect on behaviour change (Stöckli, Niklaus, and Dorn 2018).

Further, practices do not exist in isolation but are bound together in harmonious or conflicting relationships, so the transition from an unsustainable to a sustainable practice involves negotiating between competing practices (Scheurenbrand et al. 2018). Related to food waste this may, for example, include the negotiation between keeping food waste at a minimum versus buying in bulk or ensuring food safety and freshness. Which practice then ultimately thrives depends on the assemblage of material, meanings, and competences (i.e. practice bundle) that underpins it (Nicolini and Monteiro 2016). An assemblage of material and competences may include skills around food storage and preparation, the handling of leftovers, availability of relevant information, accurate labelling, access to supermarkets, packaging, meanings with which food is invested, among others (Williams et al. 2020). In turn, meanings around food – often encouraged by food supplier’s advertising – evolve especially in developed countries around a mindset of plenty, and a culture of high and even competitive consumption (Block et al. 2016).

Practice theory explains that even when a problem linked to unsustainable consumption appears to be situated on an individual consumer level, it is still affected by higher-order social, economic and cultural factors (Nicolini and Monteiro 2016). In turn, studies on wicked problems highlight that developing possible solutions to societal and environmental problems requires access, sharing, and integration of knowledge among multiple actors (Weber and Khademian 2008; Alford and Head 2017). Both perspectives align closely with sustainability transitions research asserting that the transformation of established socio-technical systems demands a collaborative approach where actors work together on various activities, including changing skills, infrastructures, industry structures, products, regulations, user preferences and cultural predilections (Schot and Steinmueller 2018). Within this collaborative and multi-actor stance, this paper focuses on citizens as *one* set of actors that is closest to problems linked to unsustainable practices. Accordingly, the next section links to consumer innovation research in order to examine the potential roles of citizens in sustainability transitions.

The potential and barriers of citizens as an innovation source

What are the sources of innovation in a social system? The dominant source of innovation are assumed to be producers. A ‘producer innovator’ is an actor who aims to profit from rather than use its innovation – e.g. through selling a new product or service (Baldwin and von Hippel 2011). Apart from firms, also research institutes and universities can be characterized as producer innovators because much of their innovation-related work is intended to spill over to producers either directly (e.g. patenting an invention and licence it to others) or indirectly (e.g. governmentally funded collaborations with organizations to help them to innovate). For example, large policy programmes, such as Horizon 2020 or the European Green Deal primarily target academia and industry as the leading actors in scientific breakthroughs and technological change. This focus on the ‘commercialization of science’ or science, technology and innovation (STI) programmes builds on an economic, firm-centred and technology-oriented tradition (Diercks, Larsen, and Steward 2019) – also referred to as the producer-centric innovation paradigm (Baldwin and von Hippel 2011; Gambardella, Raasch, and von Hippel 2016; von Hippel 2016).

The producer-centric innovation paradigm has been increasingly challenged by studies showing that also citizens engage in the creation of individually, socially and commercially important innovations (von Hippel, de Jong, and Flowers 2020; de Jong et al. 2015; Franke, Schirg, and Reinsberger 2016; Jeppesen 2021). The frequency of citizens innovating is estimated at between 4 and 6% in general populations (de Jong 2016), which means that millions of citizens worldwide engage in innovation activities and develop solutions that are new to market and have general use value (von Hippel, de Jong, and Flowers 2020; de Jong et al. 2015). This emerging phenomenon is known as the consumer innovation paradigm (Baldwin and von Hippel 2011), whereby the term ‘consumer innovator’ is used to refer to individual consumers, citizens and end-users, instead of the more general term ‘user innovator’ which can also include an organization or professional who creates an innovation in order to use it (Baldwin and von Hippel 2011; Gambardella, Raasch, and von Hippel 2016; de Jong et al. 2021). Specifically, a ‘consumer innovation’ is a functionally novel product, service, process or application, developed by citizens at private cost in their unpaid discretionary time (von Hippel 2016). As the definition highlights citizens have the capability and willingness to innovate as independent actors, thus they are not necessarily dependent on ‘producers’ or ‘state actors’ to invite them into their innovation process which is often assumed as an important condition in public management (e.g. Nabatchi, Sancino, and Sicilia 2017; Trischler, Dietrich, and Rundle-Thiele 2019). In fact, studies in sustainable innovation show that citizens perform a far more proactive function than solely being adopters or co-producers of innovations (e.g. Ornetzeder and Rohracher 2013; Hossain 2016; Nielsen, Reisch, and Thøgersen 2016; Hyysalo, Johnson, and Juntunen 2017).

The scale and value of consumer innovations is clearly documented in the literature, including research on sustainable innovation (e.g. Heiskanen, Johnson, and Vadovics 2013; Nielsen, Reisch, and Thøgersen 2016; Hyysalo, Johnson, and Juntunen 2017; Zimmerling, Purтик, and Welpé 2017; Hyysalo, Juntunen, and Martiskainen 2018), and social innovation (e.g. Svensson and Bengtsson 2010; Martin, Upham, and Budd 2015; Pel et al. 2021; Jeppesen 2021). For example, regarding sustainability challenges, citizens have been found to develop new-to-the-world innovations and local

adaptations to renewable home heating, such as solar heating systems (Hyysalo, Juntunen, and Freeman 2013; Heiskanen et al. 2014; Hyysalo, Johnson, and Juntunen 2017). Studies on social innovations, such as Alcoholics Anonymous or defector programmes for radicals, show that users change their practices by applying their own experience of problems and through trial-and-error experimenting and, together with other users, diffuse the new practice (Svensson and Bengtsson 2010). In healthcare, Patient Innovation has established itself as a global platform where thousands of patients around the world connect and share solutions they have developed themselves with no producer involved (DeMonaco et al. 2019).

However, what hampers the full potential of consumer innovations is that citizens often lack incentives and resources to make their innovations available to, and replicable by, others in the social system (de Jong et al. 2015; von Hippel 2016). It is not that the innovators erect barriers to protect or restrict access to innovations through, for instance, some form of intellectual property protection. Rather, they lack the resources or simply balk at the effort required to make their contributions understandable or easy to adopt for other actors. In fact, most citizens make their innovations freely available, which makes them to ‘free innovations’ (von Hippel 2016), because they are not driven by financial rewards or the generation of profits, but by cognitive, social or affective benefits (Nambisan and Baron 2009; Baruch, May, and Yu 2016). A problem resulting from these intrinsic drivers is that citizens do not (sufficiently) invest in innovation diffusion (de Jong, Gillert, and Stock 2018; Trischler, Johnson, and Kristensson 2020), leading to a disconnect between potentially very large adopter benefits and small but off-putting efforts required to scale innovations and net social welfare gains – the precise concern of policy-makers – go unrealized.

Still, policy-makers tend to underestimate the social value, and so under-provide the environment or resources required for citizens to develop and share their innovations (Bradonjic, Franke, and Lüthje 2019; Nielsen 2021). For example, innovation policies and related regulations (e.g. intellectual property rights – IRPs) build on the assumption that innovating actors have a high incentive to invest in diffusion because they seek to recoup profits from their innovation-related investments (Baldwin and von Hippel 2011; Gambardella, Raasch, and von Hippel 2016). Citizens typically do not innovate to generate profit but to meet a personal need – they develop a solution in order to use it (Baldwin and von Hippel 2011). Thus, innovation policies do not incentivize, but in contrast, may even hinder consumer innovation activities because citizens have limited access to resources and are confronted by increasingly stricter laws governing IPRs and online content copyrights (von Hippel 2016).

The non-diffusion of valuable consumer innovations is problematic for tackling sustainability challenges because here only widespread change can be effective: a lone citizen innovating at home cannot achieve much. Unlike ‘producer’ who are fully equipped to fund an innovation, scale it up, take it to market and disseminate it, citizens as lay actors require targeted help to scale their innovations (Nielsen, Reisch, and Thøgersen 2016; Trischler, Johnson, and Kristensson 2020). Adding to the non-diffusion problem is that consumer innovations often concern so-called technique innovations (Hienert, Von Hippel, and Jensen 2014), which focus on social rather than technical aspects as the locus of innovation (i.e. new ways of doing through social, institutional and behavioural changes; von Hippel and Cann 2021). These intangible, non-product innovations may be too private, small, or simply perceived by the innovator as not valuable to others. Yet it is exactly these contributions by citizens

that are needed for changing socio-technical systems, and thus are central to sustainability transitions. Not only is knowledge about social problems ‘sticky’ and difficult to transfer to producers (von Hippel 1994), but also might producers never face problems among citizens or might even benefit from it, just as food producers and suppliers benefit from household food waste in the sense that they sell more food. With these points in mind, we now turn to the transformative innovation policy (TIP) literature and investigate to what extent its conceptualization considers the value and specific characteristics of consumer innovations.

A narrow vs. broad conceptualization of transformative innovation policy

Governments across the world have started to recognize the transformative power of innovation, and accordingly, have introduced policies that direct innovation activities towards sustainable and social development outcomes (Weber and Rohracher 2012; Boon and Edler 2018; Kuhlmann and Rip 2018; Schot and Steinmueller 2018). These policies form part of a new frame of innovation policy – transformative innovation policy (TIP) – shifting the focus from an economic towards societal policy agenda (Schot and Steinmueller 2018). Within the societal policy agenda, Diercks, Larsen, and Steward (2019) categorize TIP into a narrow and broad conceptualization: The narrow TIP conceptualization aims to steer academia and industry actors towards addressing societal and environmental challenges through R&D and scientific breakthroughs (e.g. STI programmes supporting the development of new technologies needed for offshore wind farms). This conceptualization is closely related to ‘mission- or challenge-oriented innovations’ (Mazzucato 2016; Hekkert et al. 2020), and builds on the traditions of innovation systems and systems of innovation (Fagerberg 2018; Edquist 2013). In contrast, the broad TIP conceptualization builds sustainability transitions research (Markard, Raven, and Truffer 2012), and asserts that reaching sustainability goals requires the change of socio-technical systems (Schot and Steinmueller 2018). Importantly, such a systems change cannot be achieved through technological breakthroughs by a selected set of actors only, but requires the engagement and contributions of multiple actors, including the citizenry (Kuhlmann and Rip 2018; Schot and Steinmueller 2018).

We develop here two arguments that emphasize why the broad TIP conceptualization is needed for sustainability transitions. First, the resistance to change from the prevailing socio-technical system can be strong. Not only do actors in industries, government and civil society often benefit from the existing system, they also perceive no need to change their behaviour because of their own cognitive lock-in (Schot, Kanger, and Verbong 2016; Diercks, Larsen, and Steward 2019). To overcome this dual resistance, Schot and Steinmueller (2018) recommend opening up spaces for societal experimentation and learning, where actors collectively challenge dominant practices and collaborate on a variety of pathways towards social, behavioural and technological change. Consumer innovation research, and lead user theory in particular, show that innovating citizens engage in experimentation because they often face a problem and develop a solution to it well before producers do (von Hippel and Katz 2002; Baldwin, Hienert, and Von Hippel 2006; Oliveira and von Hippel 2011). Consequently, social experimentation cannot be left to ‘producer innovators’ but needs to involve citizens in diverse capacities, notably as innovators but also as legitimators and intermediaries (Nielsen, Reisch, and Thøgersen 2016; Schot, Kanger, and Verbong 2016). For

example, citizens may develop and take the lead on new lifestyles, preferences and consumption practices, or on a larger scale even lobby for system reform by pressuring policy-makers and firms (Trischler and Charles 2019; Jeppesen 2021).

Second, understanding demand conditions is central to innovation activities directed towards sustainability transitions (Boon and Edler 2018). Practice theory and the literature on wicked problems support this argument by asserting that access to problem-related knowledge is key to finding suitable solutions. For example, changing unsustainable consumer practices requires deep knowledge on consumer behaviour, needs, and everyday routines (Spurling et al. 2013; Scheurenbrand et al. 2018). In other words, failure to understand and address demand conditions can leave society with lock-ins and risks stopping innovations aimed at achieving a desired outcome – e.g. products or services that would cut household food waste – from being adopted and used. Here citizens again play an important role because – the locus of a problem underpinning a unsustainable practice or behaviour and related solution pathways are often closest them (Svensson and Bengtsson 2021; Oliveira et al. 2015). Not only are citizens *specialists in use* and thus close to the focal problem, they are also efficient solution developers when they have access to a diversity of problem-solving expertise in their communities (Hienert, Von Hippel, and Jensen 2014).

The broad TIP conceptualization seems to provide a promising starting point for formally including citizens as an innovation source and supporting the scaling of solutions to persistent unsustainable consumer practices. Yet, Diercks, Larsen, and Steward (2019) and others (e.g. Schot and Steinmueller 2018; Kuhlmann and Rip 2018; Hekkert et al. 2020) also stress that TIP in practice is driven by a strong legacy in economic, firm-centred and technology-oriented innovation. Other studies (e.g. Boon and Edler 2018) further point towards the neglect of the demand side in TIP, which again points towards the dominance of the producer-centric innovation paradigm. It implies that TIP is still stuck in its narrow conceptualization. In the next section, we use the household food waste problem in Sweden as an example to illustrate the possible consequences of applying the narrow TIP conceptualization.

Illustrating the role of policy in directing transformative innovation efforts

Overview

We use the Swedish food waste reduction policy and related innovation activities as an illustrative case to showcase how a policy design affects the directionality of innovation efforts among actors. In line with recent studies on the subjects of consumer innovation and TIP (Svensson and Hartmann 2018; Grillitsch et al. 2019), we purposely selected Sweden as the case because the country is consistently listed among the world's most innovative (WIPO 2019) and sustainable (Sachs et al. 2019). Supporting our argument and case selection is the recent analysis by Edquist (2019) concluding that 'Swedish innovation policy has changed from a mainly partial and linear innovation policy and has been moving towards a more holistic one'. Further, the Swedish Innovation Agency, *Vinnova*, bases its funding allocation directly on the SDGs with the declared vision of being 'an innovative force in a sustainable world' (Vinnova 2020). It is this strong link between supporting innovation activities and reaching sustainable development goals that makes the Swedish case so interesting for the

present study. However, we do not suggest that the Swedish case is the most advanced one, at least not when it comes to including citizens as potential contributors to reaching SDG 12.3. In fact, the opposite might be true since Sweden has a considerable food waste problem: Over 1.3 million tons of food gets wasted in Sweden per year (which equals 133 kg/per capita), and the by far highest amount (938,000 tons; 97 kg/per capita; or approx. 72%) occurs in households (Statistics Sweden 2018). These numbers are among the highest in Europe. To compare, the neighbouring state Denmark reports around 700,000 tons of food waste with 455,529 tons (78 kg/per capita) occurring in households (The Danish Environmental Protection Agency 2018).

We use two data sources to investigate how the Swedish policy design may affect innovation activities linked to SDG 12.3. The first data source is the policy document ‘Action Plan for Food Loss and Food Waste Reduction by 2030’ (hereafter ‘Action Plan 2030’), collaboratively developed by three governmental agencies: the National Food Agency, the Swedish Board of Agriculture and the Swedish Environmental Protection Agency. The Swedish Government tasked the collaborators with *‘develop[ing] an action plan for how Sweden can work with long-term measures to reduce food loss and food waste. The measures are to contribute to fulfilment of global sustainability goal 12.3 concerning food loss and food waste in the United Nations’ Agenda 2030’* (Livsmedelsverket and Naturvårdsverket 2018). The plan proposes 42 measures directed towards activities in investigation, research and innovation. Measures for innovation are of main interest for the current study because they inform how innovation activities are directed at addressing SDG 12.3.

The second data source concerns all innovation projects that received funding in the period 2016 to 2019 with the aim to address SDG 12.3. We obtained the data directly from the Swedish Innovation Agency *Vinnova*. Vinnova is a government agency which operates under the Ministry of Enterprise and Innovation and is the Swedish Government’s expert authority in innovation policy. The agency is also the major source of innovation funding in Sweden, investing approximately SEK3 billion (€275 million, USD300 million) in research and innovation annually. Notably, and as pointed out above, Vinnova directly aligns its innovation funding allocation with the Agenda 2030 SDGs, including SDG 12.3. Because government authorities and public research agencies control the allocation of innovation-related resources (Bradonjic, Franke, and Lüthje 2019), the analysis of funded innovation projects provides a good indication of the focus of innovations in respect of addressing SDG 12.3.

Analysis procedure

We conducted an ex-ante analysis of the Action Plan 2030 through the following process. First, two researchers each with more than five years’ experience in policy analysis and design reviewed the policy document Action Plan 2030 and transferred all 42 measures into a MS Excel spreadsheet. Second, within the spreadsheet, the same researchers independently analysed and categorized (by comparing their results and

agreeing on the final categorization) each of the 42 measures by four criteria (these criteria concern the involved actors and activities directed by TIP; see Diercks, Larsen, and Steward 2019, 883):

- (1) Type of activity (i.e. research initiative, information provision, innovation initiative, collaboration, regulation);
- (2) Actors responsible for implementation (e.g. government, research institutions, firms, start-ups, public sector organizations);
- (3) Actors involved in the implementation (e.g. policy-makers, food producers, food industry, public sector organizations, consumers); and
- (4) Outcome focus of the activity (i.e. solutions for food producers and industry, solutions for consumers/households, and solutions for the public sector and policy making).

Some of the 42 measures included distinct sub-measures. Each sub-measure, and each measure without a sub-measure, was counted as a unique ‘activity’. This gave 67 different activities specifying how food waste should be reduced in Sweden by 2030 and what actors should be involved during this process.

In addition to the policy document, one of the two researchers sourced all innovation projects that received funding between 2016 and 2019 in relation to food waste reduction from Vinnova. The obtained data included detailed information on the projects, their funding quantum, and focus. Over the four-year time span, 45 projects related to food waste reduction received funding totalling SEK44 million (€4 million, USD4.4 million). The same two researchers used the same analysis procedure as described above to determine how funding decisions mobilized different actors within the social system to tackle the food waste problem in Sweden through innovation. With the assumption that sustainability transitions require the change of socio-technical systems, and thus the involvement of different actors and a wide range of innovations (Schot and Steinmueller 2018; Diercks, Larsen, and Steward 2019), we categorized each of the 45 projects in terms of the funded actor, the type of innovation, and its intended use:

- (1) Funded source (i.e. producers, research institutions, public sector organizations, start-ups, consumers);
- (2) Type of funded innovation (i.e. technological innovation, business model design, process innovation, new service development, and new product development); and
- (3) Proposed target group (i.e. food producers, food industry (B2B), food industry B2C, consumers/households).

Combined, the data make it possible to track a policy design and related decisions allocating resources to different actors for the purpose of addressing a specific sustainability challenge – in our case, SDG 12.3. We report the findings of our analysis next.

Table 1. Activities and their focus as defined in the Action Plan 2030.

Focus of activities	Food industry (Production & supply)	Citizens/ households	Public sector/ Policy making	Total
Type of activity	12	3	4	19
Research				
Information	6	10	2	18
Innovation	10	0	1	11
Collaboration	10	0	1	11
Regulations	4	2	2	8
Total	42	15	10	67
Example of activity	Development of packaging solutions that contribute to reduced food waste in the food chain.	Web-based information with recommendations for handling fresh fruit and vegetables.	Guidance/ support for municipalities to work on food waste prevention.	

Findings

Activities targeted at reducing food waste

Table 1 provides an overview of the 67 activities we identified in the Action Plan 2030. Full details of the Action Plan including the categorization of its activities are provided in Appendix A.

As depicted in Table 1, most activities concern research ($n = 19$) and information dissemination ($n = 18$). Research activities mostly focus on the development of new measures for evaluating food waste or mapping it in the food production and supply system. In addition, the exploration of new ways to optimize food production and supply processes was also included in research. For example, sub-measure 26k proposes an *'analysis of the connection between the quality of seed, plant material etc. and its impact on waste and losses later in the chain, and what measures could be taken to improve/ensure the quality of the seed'*. Three research activities focus on households, and of these, two involve developing more accurate measures of household food waste. Only one research activity (sub-measure 42 j) calls for a consumer or user perspective when developing new methods and innovations: *'The mapping of existing preservation methods and cooking methods that contribute to reduced food waste, for example, by extending the shelf life or storage durability of the various food chains, including households, and innovations for developing such new methods'*.

In turn, information dissemination includes awareness campaigns and education initiatives to inform the public and supply general guidelines on how to reduce food waste. For example, measure 34 proposes the provision of *'web-based information with recommendations for handling fresh fruits and vegetables'*. The main actors targeted through these information-related activities are households, but restaurants and public facilities such as schools and healthcare are also included. One measure (measure 18) even includes building food waste as a topic into the teaching curriculum: *'Using school meals in teaching is made possible by scheduling school lunches. It helps to integrate food waste issues into teaching'*.

Eleven activities focus on directing innovation activities to reduce food waste. Related activities primarily concern the development of new products and technologies, such as *'better technical equipment [that] can reduce damage to products both at the harvesting stage and during transport from the field to storage, storage and*

packaging' (measure 37). The main actors driving such innovations are assumed to be food producers and suppliers. Only one innovation activity involves the public sector: 'A time-limited financial support is announced to prevent food waste in municipal catering and catering through, for example, the purchase of new equipment, skills-enhancing initiatives or the introduction of new routines' (measure 41). No innovation-related activities could be identified that consider citizens as participating actors or potential sources of innovation.

A further 11 activities were identified around collaboration. All focus on collaborations between actors in food production and supply, partly with the inclusion of research institutes and public sector organizations. Consumers or citizens are not mentioned as possible collaborators. Measure 7 illustrates the emphasis collaborative activities put on the food industry: 'Continued dialogue between industry actors who produce and manage primary products to identify measures, find incentives for reduced wastage and side flows, and develop forms for cooperation and knowledge exchange'. Finally, the category 'regulations' includes specific provisions put in place to reduce food waste. Regarding households, an example concerns new regulations for food product labelling: 'marking with "last day of consumption" is only used for goods that are very perishable and after a short time can constitute an immediate danger to human health' (measure 30).

Out of the 67 activities identified in the Action Plan 2030, 42 are linked to food producers and suppliers, while 15 are linked to households. The latter activities focus on *informing* rather than *including* citizens. This allocation of activities suggests that the Action Plan 2013 defines citizens as passive or reactive actors rather than potential contributors or a source of innovation. In October 2020 an update on the progress of the different activities was published (Livsmedelsverket 2020). In the report, the majority of activities is stated as being in progress and scaling is identified as a key requirement to ensure widespread impact. In addition, the report concludes that 'in order to achieve the target 12.3 of Agenda 2030, more parties need be active with more measures – more need to do more. Everyone who comes into contact with food needs to contribute to reducing food loss and food waste'. Citizens are again not defined as an active or contributing actor, but instead the focus is on conducting 'research on mechanisms behind different types of consumer behavior [... and] translate the knowledge into innovations that reduce consumer-related food waste in the food chain' (Livsmedelsverket 2020, 6). We move on to analyse the innovation projects that received funding in relation to addressing SDG 12.3.

Focus of innovation activities aimed at reducing food waste

Table 2 gives an overview of the 45 innovation projects that successfully attracted funding between 2016 and 2019. These projects have been identified by Vinnova as falling within SDG 12.3 and they come from different policy programmes that seek to address this goal. A detailed overview of all projects is provided in Appendix B.

As shown in Table 2, most innovation projects that received funding concern start-ups ($n = 16$), which were allocated a total of SEK7.4 million. Within this category the majority of projects are technological innovations (e.g. Compact digital laser technology platform for process control within the food industry) and new business models (e.g. Development of a climate-smart combination of restaurant and greenhouse building). In terms of focus, the funded start-up projects are primarily situated on a business-to-

Table 2. Overview of funded innovation projects.

#	Funded source	Funded amount	Type of innovation	#	Proposed target group	#	Funding example
16	Start-ups	SEK7.4 million	Technological	6	Food producers	2	Collaborative intelligence and data-driven decision making within agricultural industry (amount SEK 900,000)
			Business model	6	Food industry (B2B)	12	
			Process	2	Food industry (B2C)	1	
			Service	2	Citizens/households	1	
15	Research institutions	SEK20 million	Technological	4	Food producers	6	Smart storage solutions in the fridge of the future to reduce food waste (amount SEK 2,671,954)
			Business model	1	Food industry (B2B)	6	
			Process	5	Food industry (B2C)	2	
			Product	5	Citizens/households	1	
12	Producers	SEK15.9 million	Technological	6	Food producers	4	New grain sorting technology for improved food security and safety applied to oats (amount SEK 2,000,000)
			Business model	2	Food industry (B2B)	6	
			Process	3	Food industry (B2C)	2	
			Service	1			
2	Public sector organizations	SEK0.8 million	Product	2	Food industry (B2B)	1	Mini recycling station for increased collection of quality-assured food waste (amount SEK 340,000)
45 Total funded amount: SEK44.1 million (approx. €4 million or USD 4.5 million)							

business level (B2B), while only two projects target households (when combining the target market categories ‘food industry B2C’ and ‘consumers/households’ in Table 2). One of these projects is FoodFighters, a self-styled ‘environmental coach’ that spurs consumers to become more sustainable in their food-related practices.

Apart from start-ups, research institutions and producers are also supported as a source of innovation, while public sector organizations only play a marginal role. Notably, research institutions collected nearly half of the entire innovation funding pot (SEK20 million), while the 12 producer-led projects attracted almost SEK16 million. Similarly to the start-up projects, technological innovations represent the main focus among research institutions and producers, yet research institutions also engage in new product development (e.g. packaging solutions) or process innovation (e.g. food supply chain optimization). When turning to the focus of the funded innovation projects, a mere five of the 27 projects conducted by research institutions and producers seek to address a consumer problem (when combining the target market categories ‘food industry B2C’ and ‘consumers/households’ in Table 2). Thus, likewise to producers, research institutions primarily attracted funding for innovation projects that aim to reduce food loss within food production and supply.

Across all 45 funded projects, we could not identify a single project that could be categorized as a consumer innovation (i.e. an individual with no affiliation to a firm linked to food production and supply). Nor could we identify any initiative that aims to support consumer innovations (e.g. citizen engagement initiatives through the provision of an innovation platform or workshop labs). In fact, most funds went to solving a food production or supply problem, while innovations directed to reducing household food waste were lacking. This finding is surprising given that the largest amount of food waste in Sweden occurs once the food reaches the consumer. It also contradicts our arguments based on evidence from practice theory, literature on wicked problems, and consumer innovation research: Innovations that aim to tackle the food waste problem should start with a clear view of the demand side to ensure that they ‘unlock’ consumers from unsustainable practices. Further, given the locus of the food waste problem adjacent to the consumer, we expected that innovation activities among citizens, or organizations working closely with citizens (e.g. civil society organizations), would be proactively encouraged. Such, however, is not the case, neither in the Action Plan 2030 nor in the related funding allocation. We conclude the article with a discussion on how TIP can be broadened so that it successfully taps the innovate capacity of those actors who are closest to the underlying problem.

Towards a broad and inclusive transformative innovation policy

In this article, we developed a conceptually sound argument asserting that citizens’ contributions to sustainability transitions are important because they are close to problems linked to unsustainable practices and can develop solutions that align with (latent) needs many other people are facing. Further, based on the notion that TIP practice is guided by the producer-centric innovation paradigm (Diercks, Larsen, and Steward 2019; Bengtsson and Edquist 2020; Nielsen 2020), we used the household food waste problem in Sweden as an illustrative example to point out possible consequences for the directionality of innovations: The locus of innovation is on scientific and technological breakthroughs whereas innovations that lead to social and behavioural changes receive little attention despite they form a key part of sustainability transitions

Table 3. Overview of key arguments and implications.

Key findings	Theoretical implications	Policy implications
Transformative innovation policy practice adheres to the producer-centric innovation paradigm.	To be inclusive of citizens as actors in sustainability transitions and guide policy practice accordingly, transformative innovation policy theory must be more strongly linked to the consumer innovation research field.	Citizens need to be recognized as contributing actors who may engage in a wide range of activities, including innovating, legitimating, intermediating between user groups and producers, lobbying for system reform, or advocating new lifestyles and practices. Innovating citizens need to be supported in experimentation and the scaling of their solutions by connecting them with relevant other actors and resources.
A current weakness in transformative innovation policy is the lack of consideration of the actual locus of the problem and innovation.	Transformative innovation policy theory needs to factor in the stickiness of problem-related knowledge and the locus of different types of innovations in socio-technical systems. Social changes often start from end-users and user communities who have first-hand experience of the underlying problem.	To transform a socio-technical system and reach challenging sustainability aims such as SDG 12.3, the related policy design needs to identify the locus of the problem within the system (e.g. where does the largest amount of food waste occur). Innovating actors who are close to the problem need to be targeted and supported because they have first-hand experience of why the problem occurs. Their solutions thus may have the best fit and highest likelihood of adoption by others.
Citizens innovate but their underlying motivations differ from producers.	Transformative innovation policy theory needs to recognize that market failures differ between actors. Consumer innovations often do not diffuse because citizens, unlike producers, lack incentives to invest in innovation diffusion.	Depending on which actors are central to addressing a sustainability challenge (e.g. citizens to reduce household food waste), a policy needs to be designed to counteract the underlying market failure. For consumer innovations this market failure is most likely shown in a disconnection between first adopter benefits and the efforts required to diffuse valuable innovations.

(Kuhlmann and Rip 2018; Schot and Steinmueller 2018). Translated to the context of food waste and SDG 12.3, the narrow approach to TIP implies that while food production and supply systems become more effective in reducing food losses, the household food waste problem driven by unsustainable practices remains unchallenged and in fact increases across the world (United Nations Environment Programme 2021).

Table 3 summarizes the article's main arguments and outlines related implications for TIP theory and practice. First and foremost, the cross-disciplinary approach taken in this article brings new insights into the citizen's role in sustainability transitions, and as such, contributes to current efforts in broadening the TIP conceptualization (Schot and Steinmueller 2018; Diercks, Larsen, and Steward 2019). We argue that omitting

citizens as an innovation source sacrifices a valuable knowledge source for addressing sustainability challenges. The constantly growing consumer innovation research field supports our argument with studies showing that citizens around the world innovate in practically all sectors of the economy and social services (e.g. von Hippel, de Jong, and Flowers 2020; de Jong 2016; Franke, Schirg, and Reinsberger 2016; Jeppesen 2021). In addition, recent advancements provide a good understanding of the motivations that drive citizens to innovate (Søndergaard and Thøgersen 2021), the types of innovations contributed by citizens (von Hippel and Cann 2021), and new ways to source sticky problem-related knowledge among user communities (von Hippel and Kaulartz 2021). We call for public management and policy researchers to link more strongly to consumer innovation research because this will help to concretize the broad TIP conceptualization, and in so doing, break free from the prevailing producer-centric paradigm.

Second, this article identified a shortcoming in TIP theory and practice that needs to be addressed by future research: The missing link between the directionality of innovations and the locus of the problem. Involving those actors who are closest to the problem has been highlighted by both, innovation research (von Hippel 1994) and the literature on wicked problems (Weber and Khademian 2008). Citizens have first-hand insights on why a social problem occurs (e.g. current and inherent obstacles that prevent people from changing their practices) and possess unique knowledge on how possible solutions to these problems may look like. While many of these solutions may be about small details or hacks of how to change a specific behaviour or lifestyle – at times even too small or personal to be considered worth sharing by the innovator – they form a central element of socio-technical systems transformation (Schot and Steinmueller 2018). In other words, working towards Agenda 2030 SDGs, such as healthcare, poverty, inequality, and unsustainable consumption among others, requires the involvement of citizens because they are a significant source of behavioural innovations (von Hippel and Cann 2021), social innovations (Jeppesen 2021), and service innovations (Trischler, Johnson, and Kristensson 2020).

Third, and building on the above point, we need a better understanding of how relevant innovations developed by citizens can be supported through TIP and other activities so that they make the highest possible impact. A promising starting point are ‘transition intermediaries’, which are ‘actors and platforms that positively influence sustainability transitions by linking actors and activities, and their related skills and resources’ (Kivimaa et al. 2019, 1072). Transition intermediators can be private actors (e.g. project developers, consultancies, internet forums) and public actors (e.g. government agencies, innovation funders, policy task forces) participating in various roles. Intermediary activities can, for example, include opening up spaces for small innovation projects in response to local problems and demand (Hargreaves et al. 2013), connecting actors and relevant knowledge across local innovation projects to accelerate the build-up, adoption and use of new solutions (Hyysalo, Juntunen, and Freeman 2013), or working on policy and institutional change on a systems level to disrupt prevailing socio-technical system configurations (Kivimaa 2014).

However, we also note that research on transition intermediaries primarily focuses on the scaling of niche technologies (e.g. new technology required for the transition towards sustainable energy systems; Kivimaa et al. 2019). An important avenue for future research is therefore to investigate how actors (including public sector

organizations) can support the incubation, matchmaking and market introduction of non-technological innovations among citizens. For example, toolkits for innovation (e.g. open software, makerspaces; Svensson and Hartmann 2018; Halbinger 2018) and platforms (e.g. crowdsourcing, hackathons; Schemmann et al. 2016; Baruch, May, and Yu 2016) are common methods that are used to transfer innovation activities to non-producers, including citizens. Still as noted by de Jong et al. (2021, 6) '[a]ll these methods have been developed by producer companies and, furthermore, most research has focused on the perspective of the firm', which means that we know little from the perspective of the citizens, including their perceptions and motivations. To illustrate the significance of this knowledge gap, even when citizens make their innovations freely available to others, this does not mean that these can be simply harvested and scaled by a producer or transition intermediary. For example, seeing a firm profiting from the commercialization of a free innovation developed by a citizen may lead to the perception of unfairness, disappointment, or conflict (Franke, Keinz, and Klausberger 2013). If citizens fear such negative consequences, why should they then disclose their innovations in the first place? We call for studies to investigate these perceptual, motivational, and behavioural drivers among innovating citizens because findings will have important implications for transition intermediaries and policies aiming to counteract the non-diffusion of valuable consumer innovations.

Finally, a question that arises is whether one-time measures, such as a hackathon or crowdsourcing initiative are sufficient, or whether a more systemic approach is required to break the long-established norms and beliefs that guide the producer-centric innovation paradigm. Supporting the latter, Bengtsson and Edquist (2020) suggest the introduction of multiple measures in combination, including a) promoting innovation-friendly regulations (e.g. easily accessible knowledge protection methods), b) encouraging producers to open up R&D activities (e.g. incentivize firms to involve consumer innovators), c) supporting user communities and forums (e.g. consumer or grassroots initiatives), d) opening up data (e.g. relevant statistics related to sustainability problems), and e) providing free education opportunities (e.g. open education courses that increase technical literacy and innovation knowledge). We believe that such a combination of measures is needed to give citizens the confidence and motivation to develop and scale valuable innovations beyond personal use.

In terms of limitations, it should be noted that this article is a research provocation, which is conceptual in nature and uses a selected case as an illustrative example. We encourage the public management and policy research community to continue the discussion around the arguments made in this paper. For example, one option could be to survey policy-makers, governmental agencies, producers, and most important citizens, in order to get a full understanding of how TIPs may be (more) inclusive and supportive of citizens as an innovation source. It would be also useful to identify and report on cases where a broad TIP conceptualization is already been practiced. This, however, might not be an easy task because as Bengtsson and Edquist (2020, 22) conclude in their study 'as far as we know, no state or public agency has managed to formulate and implement a coherent policy in relation to user innovations in the household sector'. We thus call for policy-makers, funders and researchers to experiment with policies that are inclusive of citizens as key actors in sustainability transitions and addressing the numerous challenges faced in modern society and requiring a true shift in innovation's directionality.

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No potential conflict of interest was reported by the authors.

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