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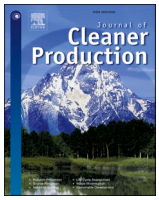

Life Cycle Assessment of Consumption Patterns – Understanding the links between changing social practices and environmental impacts

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ABSTRACT

As we are still not on track to achieve environmental sustainability through technological change, we need to further stress the importance of understanding routinized types of behaviour by private households and the environmental assessment of corresponding consumption of resources. Social practice theories allow us to understand the constitution of human activity and its embeddedness in society. In transformation research, the relevance of social practice theories has been recognized. However, there is still a lack of understanding regarding the conditions under which practices change substantially and what kinds of tools and governance approaches are suitable to foster change in social practices. We therefore propose a novel way to address the transformation of consumption patterns of private households by a) connecting social practice theories to life cycle assessment for a quantitative environmental evaluation of transformation processes and b) using narrative approaches to understand the links between several social practices and conditions for change. An illustrative study of a bottom-up neighbourhood initiative shows how specific meanings and values (expressed, for example, through meanings of "enough") affect several social practices from different consumption categories (nutrition, daily mobility, travelling). Environmental assessments further show that changing social practices across consumption categories can substantially decrease environmental pressures from private household consumption, especially in the field of nutrition. The understanding of how various social practices are connected in a nexus through narratives embodying deeper meanings point to novel ways of fostering change and the relevance of social practices related to urban or neighbourhood initiatives as an entry point to a more sustainable way of living.

1. Introduction

As humanity faces ever more pressing ecological challenges, strategies beyond technological transitions are becoming more relevant (Costa et al., 2021; IPCC, 2018; Steffen et al., 2015). This includes the alignment of the circular economy, which proposes holistic transitions of our consumption and production system, but is actually mostly focused on incremental technological change (Calisto Friant et al., 2021; Suski et al., 2023; Welch et al., 2017). There is increasing criticism as circularity is mostly promoted by tech-savvy stakeholders, neglecting social embeddedness and even technological and thermodynamical limits (Calisto Friant et al., 2023; Corvellec et al., 2022; Jaeger-Erben et al., 2021; Morseletto, 2020; Reuter et al., 2019; Welch et al., 2017; Zwiers et al., 2020). Hence, "current [circular economy] implementation fails to address the very roots of the unsustainability of contemporary society, that is a consumption culture in which materialism governs individuals' lifestyles" (Borrello et al., 2022). Bianchi and Cordella (2023) show that the circular economy in Europe is generally able to mitigate resource extraction, but that economic growth is outpacing these savings and conclude that more systemic approaches to circularity that pay more attention to sustainable consumption are necessary. Downplaying the role of the circular economy to a technocentric idea in a world of passive consumers (Lombardi and Cembalo, 2022) led to technological narratives that abandoned its "nature--inspired archetypical meaning", further leading to increasing overconsumption (Borrello et al., 2023). The focus on technological change

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is also at odds with studies ranking value retention options, that claim that the highest environmental potential within the circular economy lays in the transformation of our consumption systems (e.g. refuse, reduce) compared to technical innovations in e.g. recycling and remanufacturing (Potting et al., 2017; Reike et al., 2018).

Jaeger-Erben et al. (2021) further explain that a circular economy needs to be embedded within a circular society to reach its environmental potential. Among other things, they suggest focusing on bottom-up social innovations and new prosperity narratives, i. e. the "good life". There is a growing literature on narratives (e.g. Chabay and Martinez, 2019; Borrello et al., 2023) and bottom-up initiatives (e.g. Bienge et al., 2019; Lage, 2022) as necessary structures for establishing sustainable consumption patterns. However, a topic that is not well developed yet, is the environmental assessment of such bottom-up initiatives and emerging narratives. While there is generally a wide variety of methods for quantitative environmental assessments, they generally serve other purposes as their utilization often lack a proper understanding of social embeddedness and hence, are not able to comprehend change in our daily lives and corresponding consumption of resources (Corona et al., 2024; Font-Vivanco et al., 2022). This can lead to arbitrary choices in the problem definition and system boundaries as well as use of generic data that does not represent the actual societal change (Suski et al., 2021).

Recently, there have been some attempts to connect quantitative environmental assessments, more specifically life cycle assessments (LCA), to social theories, in order to provide a profound understanding of what is being assessed (Speck and Hasselkuss, 2015; Niero et al., 2021; Niero, 2023; Suski et al., 2021; Ellsworth-Krebs et al., 2023; Walker et al., 2023). While all of these studies rely on social practice theories and/or actor network theory, there are two distinct approaches to blend LCA with social theories. One is deep integration of social practice theories in LCA (Suski et al., 2021), the other is more of a sequence of analytical approaches that was first proposed by Niero et al. (2021) in order to tackle unintended side effects in circular economy innovations.

To avoid misunderstandings, it needs to be stressed, that neither of these studies explores the potential of social theories for social LCA, but only uses the understanding of social changes to improve environmental assessments (and vice versa). Social LCA aims at quantifying impacts on the quality of life along the supply chain, e. g. by assessing child labour and living wages in mines, production facilities etc., relying on corresponding social background data bases (UNEP, 2020). In contrast, social practice based LCA focuses on the social embeddedness of the research object leading to corresponding methods of data collection in the foreground system, while still quantifying environmental impacts and not social impacts. The potential of social theoretically informed social LCA or other impact assessment methods is open to be explored in future research.

In this article, we want to advance the discussion on LCA and social practice theory to pave the way for environmentally assessing more ambitious change in our consumption and production system by providing practical insights into the process integrating methods of qualitative social sciences and quantitative environmental assessments. We provide the illustrative case of a bottom-up neighbourhood initiative, accompanied emerging narratives and its impact on consumption patterns. We follow the general understanding of social practices as being entangled in a nexus of social practices, and that change always has an effect on several social practices (Lawo et al., 2020; Nicolini, 2010; Røpke and Christensen, 2012). More specifically, we build on recent analyses that show how social practices related to different consumption categories (mobility, nutrition, travelling) are entangled in daily life and need to be analysed comprehensively when aiming for sustainable consumption (Krog Juvik and Halkier, 2024; Samson, 2024; Suski et al., 2023). Further, to provide explanations on the mechanisms of change in the practice nexus, meanings of social practices and how they travel within a practice nexus are analysed by investigating emerging narratives. By exploring this illustrative case, we seek to shed light on the transformative power of narratives of change in reshaping social practices and ultimately reducing environmental impacts.

In the following sections, we elaborate on the theoretical foundations of our approach, discussing the key concepts of LCA, social practice theories and narratives of change and place, and their interplay with LCA. We then present the research plan adopted in the illustrative case study, detailing the data collection techniques and analytical methods employed to explore the dynamics of bottom-up neighbourhood initiatives on everyday life. A presentation of qualitative and quantitative results as well as a conclusion complete the article.

We hope that our findings will not only make an important contribution to the scientific discourse, but also inspire policy makers and communities to take a more holistic and socially informed approach to environmental assessments and sustainable consumption.

2. Theoretical background

In a traditional sense, LCA comprehensively analyses the environmental impact of products over their entire life cycle, from the extraction of raw materials through production and use to the disposal phase in order to account for shifts in environmental impacts (European Commission, 2010). Take the example of energy-saving light bulbs compared to older light bulbs with tungsten wires: the reduced energy demand in the use phase decreases the environmental impact, while the energy and resource intensive production increases the environmental impact. A comprehensive environmental assessment can quantify the net effect. The general goal of LCA is providing decision support by providing comprehensive environmental assessments.

LCA studies are usually based on linear models of cause (production processes) and effect (material flows from and into the environment), whether it be in classic process-based LCA or in Input-Output based hybrid LCA (Yang and Heijungs, 2018). This means, that a twofold increase in production causes a twofold increase in emissions. This comes with several assumptions and limitations that have already been discussed and approached, for example by utilizing non-linear general equilibrium models (Yang and Heijungs, 2018). As such models are chosen to describe material flows from a simplistic economic point of view, LCA practitioners work to adjust this method to address environmental questions regarding human action, consumption and societal transformation (Corona et al., 2024; Niero et al., 2021; Pohl et al., 2019a).

One central debate that appeared here concerns the perspective of the economic modelling in LCA in which human behaviour is only seen as an aspect of a product within a supply chain (e.g. Pohl et al., 2019b; Polizzi di Sorrentino et al., 2016; Corona et al., 2024; Caspers et al., 2023). This is at odds with consumption research, especially from the field of theories of social practices, in which products are aspects of human action (Shove, 2010; Warde, 2005, 2017 p. 86). While cautious use phase modelling is an important field of research for product LCA, proposed methods provide limited help, once the research question leaves the product-level, as it the case with bottom-up initiatives, changing narratives or generally transformative change. Economic methods to address changing consumption patterns in LCA, such as income elasticities to address rebound effects (Buhl and Acosta, 2016; Font Vivanco et al., 2018), are also not able to address transformations in consumption patterns, as they are based on generic income data, which cannot reflect specific transformative change in which consumer culture is deeply affected.

The discussed approaches on use phase modelling and behaviour are typically based on various accounts of methodological individualism, neglecting the social negotiation of society itself (Geels et al., 2015; Mylan and Southerton, 2018; Shove, 2010; Spurling et al., 2013). Missing a broader sense of social embeddedness of human action and corresponding consumption of resources, then misses the goal of LCA: providing comprehensive analyses.

2.1. Social practice theories and narrative approaches

Suski et al. (2021) laid out a framework for quantitative environmental assessments of consumption based on social practice theories. According to social practice theorist Anthony Giddens (1979), human action should not be understood as an individual act, but as a recursive negotiation of structure and agency that appears within social practices. Social structures are enabling and limiting at the same time, and are only the product of human action itself. However, social structures should not be seen as deterministic, as human agents are conceptualized as knowledgeable agents, able to critically reflect structural conditions and the way they reproduce structure (Giddens, 1984). Giddens is here heavily influenced by Marx (1852) who made the following observation: "*Men make their own history, but they do not make it as they please; they do not make it under self-selected circumstances, but under circumstances existing already, given and transmitted from the past*." Thus, change can emerge from individual agency in the carrying of social practices, but also e.g. by newly developed technologies (Shove et al., 2012). Such dynamics allow new social (proto-) practices to emerge and old social practices to cease to exist (Shove et al., 2012). From a transformation perspective, this dynamic of emerging, existing and dying of social practices is of special interest as those aspects can bring about the desired change in sustainability e.g. by changing consumption patterns. Practice theoretical informed research then does not put individuals or their behaviour, but rather social practices themselves in the focus of analysis (Reckwitz, 2002).

For comprehensive environmental assessments, it is also of utmost importance to understand that social practices are connected to each other, that they form a nexus of social practices that build the fabric of everyday life (Hui et al., 2016). This embeddedness of social practices nexuses is too complex to make changes with deliberate outcomes, which means that management or design of social practices, of daily life, is not possible. This is in line with transformation research that focuses on experiments with unforeseeable outcomes rather than policy-driven innovations (Augenstein et al., 2020; Grin et al., 2010; Loorbach, 2010, 2020; Markard et al., 2012). Samson (2024) shows how food, mobility and housing practices are interrelated in everyday life and that policies targeting any of these consumption domains will consequently affect others as well. Social practices are linked in various ways, for example based on geographical or time dependencies (Røpke and Christensen, 2012) and shared meanings (Speck and Hasselkuss, 2015; Suski et al., 2023). Lawo et al. (2020) and Klitkou et al. (2022) argue more generally for a stronger consideration of nexuses of social practices in research compared to the analysis of a single social practice. Nicolini (2010) provides a strategy of "zooming in and out of' social practices by switching lenses that enable us to analyse a specific phenomenon but also how it affects the nexus of social practices.

Suski et al. (2023) show *that* a newly developing meaning of 'enough' can manifest in a nexus related to an urban bottom-up initiative, leading to promising changes in consumption patterns. Here, enough refers to limited availability, not in the sense of distinction or poverty, but as an acceptance of natural processes and the constitution of human beings, e.g. seasons and regionality that dictate availability of local food. It was observed that 'enough' is part of urban gardening, as the joy of gardening lies to some extent in the absence of constant availability of the crops and that this idea transcends to e.g. shopping of groceries or travelling. However, without understanding the mechanisms of making and breaking links in the nexus, it is difficult to draw conclusions that provide decision support for other cases. We thus also want to study *how* meanings of specific social practices change and particularly how new meanings travel across different social practices, changing the logic of interlinkages in a nexus. Narrative analysis can be a helpful approach here, assuming that the meaning attributed to specific practices can be captured in the narratives used to describe and make sense of these practices. In particular, considering the emergence of new proto-practices where no broadly understood meaning exists (yet), narratives around these proto-practices can shed light on emerging meanings, connections made between different practices and how they relate to societally dominant understandings of certain (dying) practices and paradigms. Research on sustainability transformations shows that narratives are a central medium of the construction of meaning and catalyst for developing the capacity to act on individual and collective-symbolical levels in the context of social practices (Dobroć et al., 2023; Luederitz et al., 2017a; Riedy and Waddock, 2022; Wittmayer et al., 2019). Against the background of structure-agency dynamics embedded in social practices, the analysis of narratives can help us understand, how established orders of meaning are interpreted and translated into practices, and how they come to be critically questioned, adapted and transformed (Upham and Gathen, 2021), contributing to the emergence of new (proto-) practices and new links in a nexus of social practices. To get a grip on the complexities involved in changing social practices and emerging links between (proto-)practices, we look at narration as a creative practice where established meta-narratives and shared cultural meanings can be departed from, re-told and interwoven with different elements and experiences.

When focusing on bottom-up sustainability initiatives embedded in local contexts and aiming for social innovation and changing consumption patterns, we can draw on existing literature on narratives in sustainability transformations. First, to address meanings and links between social practices related to questions of sustainability and transformation, one can investigate overarching narratives of change. This particular type of narrative is "an individual (by a person or group) interpretation and realization of a discourse about sustainable transition, the main task of which is to initiate societal change" (Dobroć et al., 2023, p. 2). Investigating narratives of change allows for an in-depth understanding and uncovering of the fundamental ideas represented in the meaning of the studied social practices in regard to how and why things should change, what engaging in a specific practice means and how it informs the thinking and activities of those involved (Wittmayer et al., 2019). Second, research on local and bottom-up driven transformation processes and initiatives has shown that sustainability challenges become tangible in local contexts and that people experience motivation and self-efficacy especially when they become engaged in something that matters to them personally, a sense of belonging or place attachment (Frantzeskaki et al., 2018). Local context thus needs to be viewed not just as the setting of a social practice, but rather as part of the meaning of a social practice drawn from a sense of place (Stedman, 2002, 2003; Stedman and Ingalls, 2014; Stewart et al., 2004). Investigating narratives of place related to bottom-up neighbourhood initiatives allows for an in-depth understanding and uncovering of the (usually) positive emotional bond people form with their environment, where they become personally attached not so much to a place as such, but to the meaning they ascribe to this specific place (Frantzeskaki et al., 2018). Since we are studying (proto-) practices in the context of neighbourhood sustainability initiatives, we propose looking into narratives of change and narratives of place – both of which are potentially relevant "bridges" in the nexus of newly emerging proto-practices.

Following this line of practice theoretical considerations, we want to address consumption patterns in their complexity and as part of social structures, without being forced too strictly into the limitations of linear economic supply chain modelling. Consumption is understood here as the 'moment' in social practices (Warde, 2005, 2017), where material goods are used up and turned into waste (Røpke, 2009; following the broader definition of consumers by Williams, 1976).

2.2. Integrating life cycle assessment and social practice theories

Consumption as the conversion of goods into waste is something that LCA has in its DNA, as this is being described in detail during the life cycle inventory phase, where, along the supply chain, material inputs and outputs are being balanced. LCA can then be applied to calculate the consumed materials in the nexus of social practices in a classic product

footprint manner. As an analysis of the nexus of social practices already accounts for any higher order effects, no additional consideration of economic or psychological rebound effects or any other spill over effects are necessary (Galvin and Gubernat, 2016; Sonnberger and Gross, 2018).

Two diverging ideas have been proposed to blend LCA with social practice theories with some similarities but also some fundamental differences.

The first approach is a rather sequential analysis of LCA and social practices. Niero et al. (2021) present a framework to address "indirect shifts in consumption patterns" while transitioning from a linear to circular economy. They suggest that in order to provide meaningful decision support, LCA practitioners first need to understand "how things work" and that this entails qualitative analysis based on practice theory and/or actor network theory, or more basically work from the field of sociology of science and technology. It is proposed that practice theoretical approaches are being used in the very beginning in order to identify functional units and system boundaries. However, discussing the example of soap packaging, it is shown, that this approach mainly focuses on empirically sound use phase modelling. The analysis of social practices and actor-networks seems to barely affect the analysis of material flows, but are additional analyses that help to make more sense of the results. The indirect effects of circular models, at least in the provided example, do not address other areas of household consumption, but rather diverse handling of different soap products (dispensers etc.). It actually is not exactly clear what it means to "address unintended side effects" and whether it means to include them in the LCA or only address them separately and qualitatively. This aspect is more clarified in a follow-up article in which four consecutive steps are described to analyse and assess packaging related regulations (Niero, 2023). First material flow analysis, then actor-network mapping, then LCA, then an analysis of social practices. This idea of sequentially adding perspectives in the analysis is very well described in the empirical work of Ellsworth-Krebs et al. (2023) in which practice theory is used in order to interpret the result of an LCA of hair removal techniques. Here, an LCA of several product alternatives is conducted first, and then the results are discussed in, among others, a practice theoretical manner.

This sequential approach is quite close to actual products, even while looking for the social practices of which they are part of (razors are part of shaving, soap is part of showering).

The second approach that we want to follow here starts from a different ontological position and aims for integration (rather than sequence): The sequential approach builds on switching the ontological lenses in the process. Actor-network theory, which understands the world as a network of human and nonhuman actors, is incompatible with a view of the world as a net of social practices, which leads to the idea of conducting the analyses in series. The integrative approach builds on this fundamental ontological assumption of social practice theory, namely that the world should be viewed and analysed as an infinite net of social practices. The whole LCA then follows the idea of social practices without switching the ontological perspective, which affects various stages in the analysis, e. g. specifying the decision-making context in the goal and scope phase and data collection in the life cycle inventory stage. We build on previous work following this integrative approach (Suski et al., 2021).

Here, the comprehensiveness of the LCA is achieved by conducting an analysis of the nexus of social practices, that serves as the system boundary of environmental modelling. The proposed framework primarily aims at the assessment of aspects of changing sustainable consumption patterns and suggest that changes in one domain of everyday life, e. g. leisure activities, might affect other domains as well, like mobility and nutrition social practices (Samson, 2024). It is proposed to zoom in and out of social practices in order to comprehensively analyse the social practice under investigation and its nexus (based on Nicolini, 2010). As the focus is on environmental assessments, it can be beneficial to focus on environmentally relevant social practices in the analysis of the nexus. As already pointed out by Røpke and Christensen (2012), the focus is on insights into environmental effects of specific consumption patterns that remain hidden in current approaches, and not necessarily on a definitive calculation of absolute and comparable numbers.

The integrative approach followed and developed further here is more focused on transformative change in our consumption system, providing the example of bottom-up neighbourhood initiatives and its effect on daily routines, e. g. by shared meanings.

Going beyond describing and environmentally assessing changes within the nexus of practices, providing an understanding the logics behind it, such as the underlying transformations in the nexus of practices, will allow for more targeted conclusions and interventions.

3. Material and methods

The methods applied to explore the concept of social practice-based LCA in an illustrative case are standard methods from the field of qualitative social sciences and life cycle assessment. What stands out is the combination of these diverse methods for data collection and data analysis from both fields of research. The very specific choice of methods for data collection, especially from the field of qualitative social sciences, were partly influenced by case-specific requirements, including Covid-restrictions. In this sense, the described process of data collection serves as an example and not a rigid structure for future research.

The research plan (see Fig. 1) follows the proposed basic steps to environmentally assess social practices based on Røpke and Christensen (2012) and Suski et al. (2021).

1. Identification of the nexus of social practices associated to the research object, which then serves as the system boundary for the LCA model
2. Understanding the logics behind observed changes in the practice nexus
3. Quantification of material base of identified social practices
4. Environmental impact assessment of the nexus of social practices

The research plan in Fig. 1 shows the importance of the mixed-method approach in order to describe, environmentally assess and understand consumption patterns (as an aspect of a social practice nexus). The quantification of environmental impacts, i.e. building the model of the LCA, is based on an in-depth understanding of the analysed social practice and how it changes. This makes the interdisciplinary process mandatory in contrast to other interdisciplinary methodologies where "only" optional layers of analysis are added to increase the value of the project, e.g. in the interpretation of results (see chapter 2.2).

As the nature of social practices is elusive to some extent and no definitive nexuses of social practices can be found, it is important throughout the research process to specifically analyse environmentally relevant social practices, such as flying (Lee et al., 2021), daily mobility and nutrition (Poore and Nemecek, 2018; Rütt et al., 2022). This does not mean that they have to be included in the system boundary and therefore the environmental assessment, but simply that they are not overseen. Additionally nutrition and mobility practices are reported to play central roles in the structure of daily routines, so that they are useful as reference points in data collection (Castelo et al., 2020; Klitkou et al., 2022).

3.1. Data collection

We analysed a bottom-up neighbourhood initiative in the city Wuppertal (Germany), more specifically in a neighbourhood called *Arrenberg*. The Arrenberg initiative is group of people and small local companies that aims at improving the standard of living and increasing sustainability in the quarter. Within the initiative, there are several interwoven activities, many of them food-related (food sharing, a Farmbox for collaborative food production, an open restaurant day,

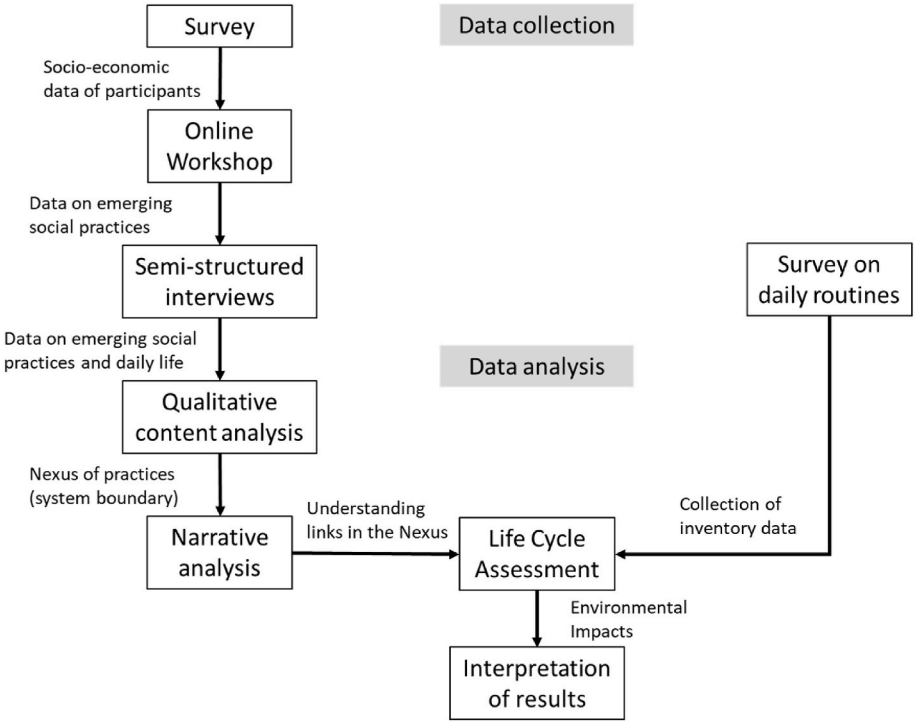

Fig. 1. Interdisciplinary research plan.

regular free barber shop days and clothes swapping days etc.).

The data was collected in two steps. First, we conducted an online workshop accompanied by two surveys, and later did semi-structured interviews. All participants took part as private citizens who are active in at least one of the many activities by the Arrenberg initiative. Most participants live in the Arrenberg neighbourhood.

3.1.1. Workshop and surveys

The first phase of data collection took place in late 2020 and consisted of a workshop and two surveys. The workshop took place via online video call, which was recorded and transcribed. All people active in the Arrenberg initiative were invited by a central organiser, using their internal mailing list. The study participants are the ones who responded. This means that all study participants are in some way or another actively involved in organising or carrying out mentioned activities, and are not just passive consumers of e. g. second hand clothes or saved food. While this makes this group of people even less representative for the people in the neighbourhood, it helps to illuminate the environmental potential that bottom-up neighbourhood initiatives can have in a relatively early phase and with limited diffusion.

The workshop was accompanied by two surveys. In the beginning, we used a short online questionnaire to record socio-cultural and economic background data (age, gender, nationality, diet etc.) as well as their dietary. After the workshop, the participants were asked to fill out a survey in the form of a timetable with their daily schedules in the fields of work, household activities (shopping, laundry), leisure and family (children, pets). Beside the daily activities, they were asked to name the usual timeslot, where the activity took place, the mode of transport they used (if any), the number of participants in the activity and the regularity with which it took place. In addition to daily routines, the participants were asked to list their holiday trips.

Table 1 provides an overview of data collection. It also shows the problems presented by switching from an in-person format (as was originally planned) to an online format (due to covid restrictions), as the surveys had a relatively low response rate. This was due to a partly elderly, tech averse group and technical complications (doing everything on a smartphone instead of a notebook) and due to the sharing of devices (4 people participating via one Laptop).

Table 1
Methods and goals of the first phase of data collection.

	Goal	Question/Task
Survey 1 (7 People)	Sample structure	Age, education, income etc.
	Materials of eating-related social practices	I eat meat: regularly (5–7 times a week), sometimes (1–5 times a week), never or rarely (vegetarian), no animal products (vegan)
	Meaning of neighbourhood practices	I participate in the initiative because …
Workshop (12 people)	Competences of neighbourhood practices	If you had to be replaced, how would you describe what you are doing in the Arrenberg Initiative?
	Sense of place, Mobility practices	Show (on a map) and describe important places in your daily life.
Survey 2 (5 people)	Network of social practices, materials of mobility practices leisure practices	Show me roughly what you were doing in an average workday/ weekend in October 2020. Also tell me where, with whom and how you got there, and how often.
	Travel practices and their materials	Please tell me about your travel activities in 2019 (where, mode of transport, how often, how many trips).

3.1.2. Interviews

Everyone who participated in the online workshop was later invited to participate in semi-structured interviews conducted in late 2021. The goal was to identify links between the social practices based on a shared meaning and to identify narratives as links between social practices. The seven semi-structured interviews were conducted via online video calls, recorded, and lasted between 38 and 108 min each. Table 2 provides an overview of the interviewees, showing that the sample is quite homogeneous in regard to age, gender, education and ethnicity. The elderly, tech averse food sharing group did not respond to online video calls.

The interviews were structured in three parts. First, the interviewees

Table 2
Overview of the interviewees involved in emerging neighbourhood practices.

No.	Main neighbourhood practice	Age	Gender	Education	Migration background
1	Urban gardening	32	Male	University	No
2	Urban gardening	37	Male	University	No
3	Urban gardening	32	Female	University	No
4	Urban gardening, open workshop	35	Male	Vocational training	No
5	Free barber shop	38	Male	Vocational training	No
6	Clothes swap	35	Female	University	No
7	Food-related sharing, e. g. open restaurant day	47	Male	University	No

were asked to describe what they do with regard to their activities in the neighbourhood initiative and how they came to be there. In the second part, the interviewees were asked to describe life in the Arrenberg neighbourhood and, if they live somewhere else, to what extent this Arrenberg way of life can be transferred. This part focused specifically on the role of their neighbourhood in the nexus of emerging practices. The focus here was on place attachment and its relevance to their consumption. In the third part, the interviewees were asked to describe their eating, mobility and leisure habits, i. e. the role of food consumption in daily life and what they seek in their leisure time. This part focused specifically on the most environmentally-relevant consumption categories. While leisure is traditionally not that environmentally important (compared to living/heating, for example), it serves the purpose of identifying what is of key importance to the practitioners outside volunteering. Leisure also includes travel in our interviews, which makes it far more environmentally relevant. The environmental focus of specific aspects was never mentioned by the interviewer.

The interviews were recorded and transcribed (clean read) to conduct a qualitative content analysis (Mayring, 2014). The coding was done using MAXQDA, using a phrase as the coding unit. The code system was derived inductively and built around the meanings of social practices in daily life. Two complete coding runs where necessary, the first with an ever-growing code system and the second with a final static code system. Building on the final code system, narratives of change and narratives of place were identified and summarized from the relevant codes.

3.2. Environmental assessment

The model for environmental assessment is based on the material aspects of social practices that are connected to the bottom-up neighbourhood initiative. Not the various and very diverse neighbourhood activities themselves are in focus, but their impact on consumption patterns in the nexus of social practices. As will be further shown in the results section, the identified social practices are grocery shopping, urban mobility and travelling.

The functional unit of the LCA, which is the unit of analysis, is the carrying of the emerging bottom-up neighbourhood practices by a person for a year (e.g. gardening for a year). This is a little problematic as it seems close to household studies (Greiff et al., 2017; Lettenmeier, 2018; Sala et al., 2019) and might imply individualism where there is none. However, we do not assess individual connections between social practices, but rather a practice nexus in the making, and only use this 'per person' scale to make the results easier to interpret. Scheurenbrand et al. (2023) made it clear that analysing social practices to study sustainability might include observing or interacting with particular people, but that this does not mean that individual actions are represented in the study.

For the impact assessment we used the ReCiPe 2016midpoint (H) life cycle impact assessment method and more specifically the indicators climate change (GWP100), water use (water consumption potential, in m^3), land use (agricultural land occupation, in m^2*a crop-Eq.) and material resource use (surplus ore potential in kg Cu-eq.).

The quantification of the materials in social practices is based on the surveys for the affected consumption patterns. In order to get an environmental potential, those are put in comparison with a counterfactual baseline of the community not existing, which relies on secondary material and assumptions. All necessary data to conduct the environmental calculations can be found in the appendix.

4. Results

First, the qualitative results on the nexus of social practices are presented in order to understand the phenomenon under investigation and to identify system boundaries for impact assessments. Then results of the environmental assessment are shown.

4.1. Nexus of practices and system boundaries

The results of the interviews and online workshop show that several household related social practices are entangled to each other and that the emerging bottom-up neighbourhood practices of the Arrenberg initiative have distinct impacts on urban mobility, grocery shopping and travelling (see Fig. 2). As many emerging social practices related to the Arrenberg initiative show strong similarities in how they are organised and perceived, and as they are still in early development, we conceive them as one social practice of bottom-up neighbourhood activity. Shared meanings of enough are shown to be powerful in reshaping consumption in given social practices. 'Enough' represents the idea of a good life that is connected to limited access to goods and services and hence a specific valuation of the material world often accompanied by a general deceleration of life. Food sharing promotes waste reduction and re-evaluation of what is still good food, urban gardening promotes seasonal food supply, clothes swapping offers an alternative to shopping new stuff etc. A few quotes from different interviewees shall exemplify these connections by shared meanings.

On groceries:

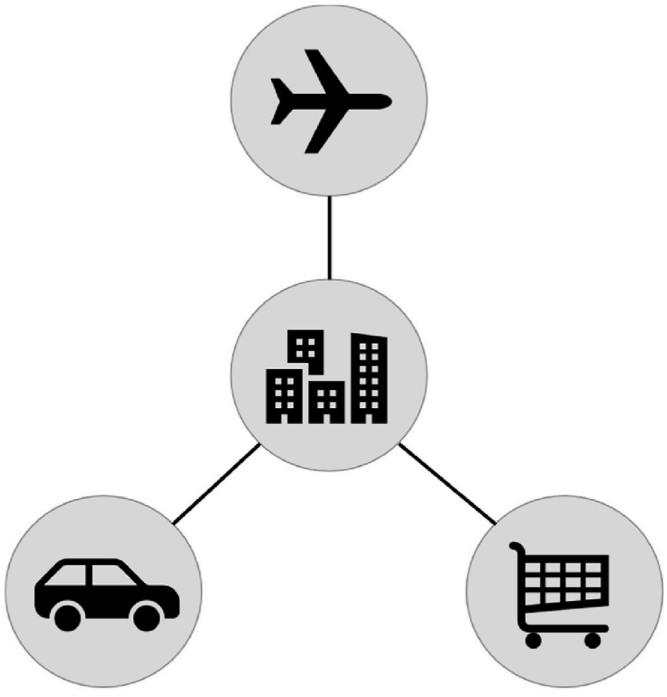

Fig. 2. Nexus of social practices: bottom-up neighbourhood practices connected to travelling, urban mobility and grocery shopping serving as the system boundary of the Life Cycle Assessment.

"I'm not of the opinion that we have to eat strawberries in winter. But what does the market do? Puts strawberries out for us that look red, but taste just awful."

"I'm not a vegetarian myself, but we try to eat very little or relatively little meat, and if I do, it's usually good quality meat."

"But when you combine the two and grow your own products and collect food from food sharing, and then cook it, that's actually the greatest feeling for me."

On urban mobility:

"I think walking clears your head and you can also see something of your surroundings. For me, there's nothing better than walking."

"I still walk a lot though and I kind of enjoy walking. I've established it as part of my everyday life over the last five or six years."

On travelling:

"And otherwise, we really love taking the train. I can do everything during the journey. I can sleep, eat, drink. I can have a beer or a glass of wine or anything else. I can sleep, I can watch a movie, I can read, I can work. I still arrive at my destination stress-free."

"Well, I keep thinking about Asia once, but Europe has such wonderful places, too. I was such a big Lod of the Rings fan back then and thought the landscape was so great but after my semester abroad in Norway, the landscape there can be compared pretty well with New Zealand landscape that I know from pictures. [.] So, will I actually do it? Let's see."

The interviews and the results from the online workshop reveal that the study participants share a specific narrative of place related to the Arrenberg neighbourhood. This narrative is intertwined with a narrative of change, both in the practices they engage in and in their personal lives.

Regarding the Arrenberg neighbourhood, a specific narrative of change can be identified, describing a problematic past, important characters and events leading to a brighter future: Until ca. 15 years ago, the whole neighbourhood was a poor district known for its high crime rate. Everyone who could afford to leave Arrenberg left. However, some local entrepreneurs stayed and invested time and money to develop the area into a socially open and environmentally sustainable neighbourhood and started the Arrenberg Initiative. While we do not intend to assess the overall results, we did observe that a strong narrative of self-empowerment for change and sustainability was established, which everyone is using and reproducing. It is a different version of the 'rags to riches' narrative, whereby it is not the individual but rather the whole neighbourhood that benefits. While the transition comes with typical gentrification aspects that make some quite rich, it is also noteworthy that the narrative of change in Arrenberg is not about economic riches whatsoever but rather the standard of living, active communities and sustainable use of resources, even if it was initiated by entrepreneurs.

This interlinked narrative of change and place has shown to be a crucial connection between several emerging social practices. One aspect of this is the sense of place attached to specific locations in the neighbourhood and how they connect people as a basis for the activities in the initiative. Two places in particular were shown to be relevant for connecting people and social practices, namely the office of the Arrenberg Initiative and a café ('Café Simonz'). Both are central to the establishment of any new neighbourhood activity. While the office works as a formal way to address new ideas or initiatives, the café is a rather informal place to meet and discuss ideas.

"*Well, the most important thing is certainly Café Simonz and the courtyard of Café Simonz, which is the nucleus and perhaps the heart of Arrenberg, you really have to say*."

During the discussions on further important places in Arrenberg or anywhere else in the city, it became clear that this multifunctional neighbourhood provides many of the daily needs and, hence, further increases place attachment, from grocery shopping to restaurants, forests, playgrounds and schools etc. While there are highly popular places nearby, including the nightlife district of the city which is directly adjacent, the data show relatively little interest in leaving the Arrenberg neighbourhood. Several interviewees describe the Arrenberg neighbourhood as a small village within a bigger city which, for them, combines the best of both worlds.

"*We Arrenbergers simply have a village atmosphere. In this big city of Wuppertal, you are actually in the centre, but completely self-sufficient, somehow. So, everyone really knows everyone here*."

This sense of place can also be observed when compared to experiences outside Arrenberg. Three interviewees who are actively involved in urban gardening actually live somewhere else. When asked whether they could transfer anything they like about Arrenberg to their own neighbourhood or if they would like to be active there as well, they denied as they feel that the Arrenberg feeling simply cannot be duplicated. Besides any cultural aspects of places, this also shows the relevance of central organization within Arrenberg. Even when compared to other neighbourhoods within the city that are known to be nice and open (Ölberg and Luisenviertel, for example), Arrenberg seems to be special in its sense of place:

"*But I have a lot of friends from Ölberg and Luisenviertel and they say that this thing of everyone knowing everyone is still completely different here. So, I don't know. When we still had our bakery here, sometimes it took me 45 min to get to the bakery because then you meet him, oh hi, and then someone else comes along, and then you chat*."

Another aspect is that several interviewees explained that they did not have anything to do with sustainability before participating in the neighbourhood activities, but then reported having internalised the Arrenberg narrative of change and sustainability associated with it:

"*So, I have changed completely in that respect, because I think much more about what socio-critical issues are. And we have a very critical topic in sustainability*."

Another interviewee reported a similar experience.

"*At the beginning, we were a bit concerned about sustainability, I would say we knew about it, we knew what was behind it, a bit, but not yet in such detail. And of course, this has been deepened by the Arrenberg Initiative and then especially by the Farmbox project, and meanwhile it is also part of our everyday life*."

This can also be seen by comparing the answers of the survey on motivation to participate in those activities with the answers in the interviews to the question on how it all started for them. While in the beginning there were some personal interests, swapping clothes with friends to get new ones, enjoying doing manual work, taking a deep dive into proton radiation for indoor farming etc., the practices have been loaded with saving the world by saving resources and improving liveability for everyone in the neighbourhood. Here, we can see that a strong narrative of place, its connection to a broader narrative of change and sustainability and narratives related to other values (for example, community, manual work, leisure etc.) have become interwoven and can help to gain a deeper understanding of the diffusion of meanings in the nexus of practices.

4.2. Environmental impacts

The change in the social practices associated with the bottom-up neighbourhood initiative can lead to a significant reduction of environmental impacts. Table 3 shows the environmental impacts of social practices as if they were unchanged of the neighbourhood community. When it comes to driving, we only looked at short distance driving, as no impact on driving longer distances could be observed, so the results do not show driving as a whole. Groceries, on the other hand, are quite comprehensive. With regard to travelling by plane, one has to acknowledge the limited share of people travelling by plane every year. This means we cannot say that grocery shopping is worse than flying. One long distance trip by plane (9,000 km) is associated with nearly 4000 kg CO_2-eq. and hence more than a whole year of grocery shopping. Fig. 3 provides an overview of changes in the carbon footprint of given social practices as a result of connecting to bottom-up neighbourhood practices. It shows that the social practices of travelling, shopping

Table 3
Environmental impacts of social practices in the unchanged practice nexus (baseline).

	Carbon Footprint in kg CO_2-eq./yr.	*Water Use in m^3/yr.*	*Land Use in m^2/yr.*	*Minerals in kg/yr.*
Driving (short distance)	169	0.43	3.8	4.8
Grocery shopping	3523	245	10676	76
Travel (plane)	422	0.14	0.92	0.98

groceries and driving remain as such, but that their environmental impacts decrease due to changed materials (e.g. changing diets) or reduced effectiveness in appropriation (e.g. people flying less).

Looking at the different indicators, we can see that water use and land use are primarily relevant for grocery shopping with a factor of ca. 11,000 between land use for shopping and travel, compared to a factor of eight for the carbon footprint. Here, it must be explained that even though the impact assessment method describes the land use indicator as "agricultural land occupation", the indicator also includes land use by traffic and urban built environment. Comparing travelling by plane and driving, we can see that travelling by plane is quite carbon intensive, while driving has higher impacts regarding water use, land use and minerals. This is due to the high energy demand and long distances of flights, while using little built infrastructure.

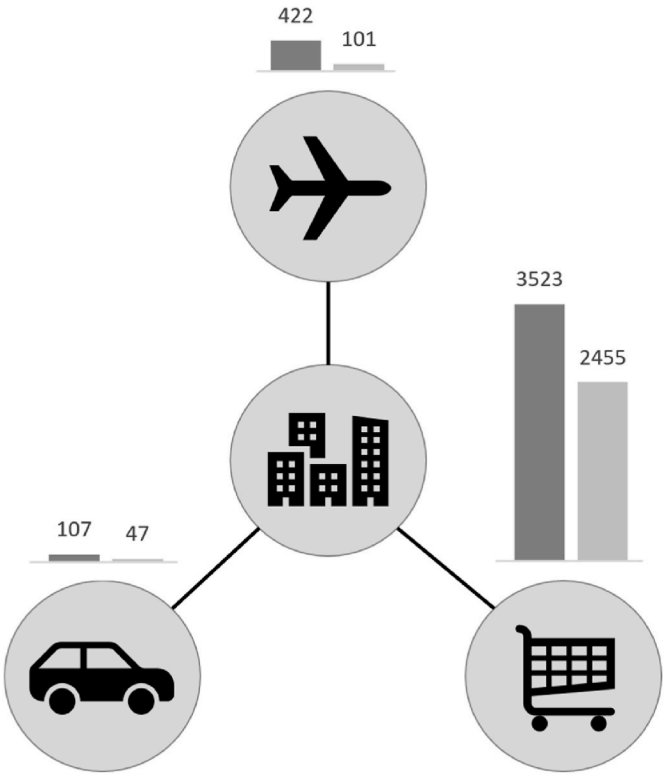

Fig. 3. Carbon Footprints in kg CO_2-eq. per person and year in the nexus of social practices. Darker bars represent the status quo, brighter bars represent changed social practices.

The carbon footprint for grocery shopping is quite high compared to the other practices, showing that an environmentally relevant social practice is deeply affected. In a literature review, Rütt et al. (2022) report that an average diet (medium meat intake) corresponds to a carbon footprint of 1.8–3.5 tonnes CO_2-eq. per person and year, which means that we have calculated results that are relatively high for an average food intake. We suspect that this has something to do with system boundaries and choice of processes in ecoinvent. The present analysis includes average transport processes from the field to further processing using market processes which leads to increased environmental impacts.

Table 4 shows the environmental impacts of the affected social practices. The environmental impacts of driving (short distance) go down by 56% throughout all indicators. This is equal to about 95 kg CO_2-eq. per person and year. Grocery shopping shows a reduction from 15 % (water use) to 30 % (carbon footprint) by cutting meat to twice per week. This reduces the carbon footprint by about 1000 kg CO_2-eq. per person and year.

The change in travelling practices would lead to a reduction of environmental impacts from 4 % (land use) to 76 % (carbon footprint). The carbon footprint decreases by 321 kg CO_2-eq. per person and year.

Overall, we can see that the carbon footprint decreases by 36%, water use by 15%, land use by 19% and minerals use by 20%. While we can see that changed social practices for short distance urban mobility has the highest relational reduction in environmental impacts, the absolute reduction is relatively small as there is not so much motorized short distance mobility. However, there might be other indicators that are more relevant here (noise, particulate matter, urban space and well-being etc.). The potential to reduce greenhouse gas emissions by not using aeroplanes to travel is more than three times higher than changing driving practices (ca. 320 kg CO_2-eq.). Reducing meat intake has the highest environmental potential (e. g. 1068 kg CO_2-eq.). With an estimated carbon footprint of 8.8 t CO_2-eq. per capita and year in Germany (OECD, 2023), the identified reduction potential of changed consumption patterns due to the bottom-up neighbourhood initiative of 1.48 t CO_2-eq. per capita and year makes up for 17 %.

5. Discussion

The social practice-based LCA that we have presented in this article shows that it is very important to have the tools (theories and methods) to reach a comprehensive understanding of the phenomenon under investigation. Life cycle assessments claim to provide a comprehensive picture, making it possible to derive the best solutions to reduce environmental impacts. However, this claim holds true primarily when it comes to strictly supply chain-related questions. Social innovations and transformative changes do not fit neatly into simple supply chain logics,

Table 4
Environmental impacts of social practices in the practice nexus after being affected.

	Carbon Footprint in kg CO_2-eq./yr.	*Water Use in m^3/yr.*	*Land Use in m^2/yr.*	*Minerals in kg/yr.*
Driving (short distance)	73.9	0.19	1.7	2.1
Shopping groceries	2455	208	8642	66
Travel (plane)	100	0.086	0.88	0.72

as this approach leads to oversimplified and incomplete representations of reality. Instead, analysing the nexus of social practices offers a novel system perspective, essential for seriously addressing the goals of a circular economy and sustainable society. The proposed and tested social practice-based LCA thus serves as a valuable addition to the array of LCA approaches, each fulfilling various purposes.

In the case of a bottom-up neighbourhood initiative, we could show that there are distinct features attached to their meanings that make it affect a broader nexus of social practices. It is not the swapping clothes or sharing of space in an urban garden as such that provides the relevant potential for reduced environmental impacts, but rather the cultural shifts, expressed in narratives of change and place leading to changing patterns of urban mobility, travelling and grocery shopping. A dietary shift in particular results in big shifts toward more sustainable consumption, even though we cannot draw conclusions regarding any mono-causal strains.

By analysing and assessing bottom-up neighbourhood initiatives in such a way, this study goes way beyond existing literature on environmental assessments of circular economy measures, which are more product- and technology-focused. The results clearly show how an active and organized local community in multifunctional neighbourhoods does not only raise satisfaction with life and rents but also the environmental performance of everyday life. By exploring narratives of change and place the interplay between people and their environment, emphasising the need for relationships that enhance our sense of connectedness and meaning could be revealed. Here, we unveil a new perspective that goes beyond the mere circulation of resources but promotes a circular society. This interplay of ideas paves the way for socio-cultural change, where bottom-up initiatives become a catalyst for the cultivation of a more harmonious and sustainable coexistence. In this way, narratives of enough are at the heart of the meanings attached to newly emerging proto-practices, without individuals ever talking about renunciation or sufficiency.

We have also shown that this kind of social science thinking in environmental assessments is open to many kinds of approaches that are helpful in describing the observed world, such as narratives of change and place. Narratives that connect different social practices, in our case draw on values relating to community and sustainability that travel across emerging social practices which are generally understood more in terms of alternative economic systems. So, understanding changing social practices more deeply can be improved by looking into nexuses of social practices and by inductive approaches to discerning the narratives and meanings attached to them and emerging in specific cases and contexts.

6. Conclusion

The social practice-based LCA approach outlined in this study offers a novel and comprehensive perspective on environmental assessment, particularly in the context of transforming consumer culture to reach a circular society. It shows that in impact assessments the idea of comprehensiveness needs to be critically reflected and accounted for and that including supply chains alone might be insufficient for takes on circular economy or sustainable development that exceed product optimization.

The empirical findings indicate that there is no single neighbourhood social practice that requires top-down policy support. Instead, the availability of open spaces for citizens to meet and organize their lives is more generally crucial. This can be facilitated by adapting urban development funding rules and fostering policy sensibilities that extend beyond sector-specific solutions, such as food labeling.

To further develop social practice-based LCA, future research should expand empirical analyses through case study-oriented approaches, enabling researchers to generalize their understanding of social practices. Additionally, focusing on the appropriation of social practices could offer deeper insights into how a circular society might evolve and expand. By inviting further exploration from social sciences and humanities, this research aims to inspire meaningful environmental analyses that support the transition to a sustainable circular society.

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CRediT authorship contribution statement

Pauline Suski: Writing – review & editing, Writing – original draft, Visualization, Supervision, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Karoline Augenstein:** Writing – review & editing, Writing – original draft, Validation, Funding acquisition. **Kathrin Greiff:** Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix

Assumptions and data sources for environmental modelling of grocery shopping, driving and travelling.

Grocery shopping

The environmental impact of nutrition mainly depends on the ingredients and, here, on the share of meat (especially beef) and dairy products (Poore and Nemecek, 2018; Rütt et al., 2022). In order to take into account a transforming grocery shopping practice where the intake of animal products is reduced, we modelled two different dietary patterns: average meat intake (3–7 times per week, the status quo) and low meat intake (1–2 times per week, representing change within the practice nexus). This quite drastic change in dietary patterns we found in our data cannot be explained

by aspects of the Arrenberg initiative alone, but rather is accelerated by them and embedded in a trend to reduce meat intake (Statista, 2023a). We oriented our calculations on Rütt et al. (2022), who used food consumption data for western Europe from the FAO[1] as a baseline and combined it with food patterns of reduced intake of animal products for the other scenarios based on Orlich et al. (2014). In addition to Rütt et al. (2022), we not only included the carbon footprint in our calculation but also the water use, land use and mineral depletion. The calculations of the environmental impacts of food products are mainly based on ecoinvent 3.9. Additional calculations were conducted for food products that are not included in ecoinvent 3.9 and were based on literature (for example, noodles are based on Gnielka and Menzel (2021) and eggs are based on Estrada-González et al. (2020) and Guillaume et al. (2022)).

Processing, storage, preparation and food waste in those life cycle stages were excluded. This leads to an overall underestimation of the environmental impacts of food-related practices including grocery shopping. For a more detailed description of the diet calculations see Rütt et al. (2022).

Driving

The calculations for daily urban motorized private transport are of utmost important to us when it comes to short distances (less than 5 km) as it is said that this distance can be easily substituted by walking or riding bicycles. In big German cities, more than 40% of daily routes driven are shorter than 5 km (Nobis and Kuhnimhof, 2018). As we learned in our empirical analysis, people in the Arrenberg Initiative are not entirely reluctant to use cars, but many only use them in very specific situations, otherwise switching to other modes of transport, especially walking.

Statistics on daily mobility in Wuppertal (Scheer et al., 2021) show that driving a car is less relevant for distances of less than 1 km, but this increases quickly above that line (see Table 3). Distances of between 2 and 5 km represent the biggest share in daily mobility (29%), while the shortest distances only represent a 4% share (under 0.5 km) and a 7% share (0.5–1 km) respectively (Scheer et al., 2021). At a reported overall daily mobility of 30 km (weekdays, excluding travelling), given shares for each distance and the modal split, we are able to calculate distances travelled using each mode of transport.

Table 3
Share of modes of transport in Wuppertal for different distances in daily mobility (based on Scheer et al., 2021)

	Walking	Cycling	Driving	Public transport
Under 0.5 km	88 %	5 %	7 %	1 %
0.5–1 km	81 %	4 %	14 %	2 %
1–2 km	53 %	9 %	31 %	6 %
2–5 km	17 %	10 %	59 %	14 %
5–10 km	3 %	8 %	74 %	15 %
10–20 km	0 %	9 %	80 %	10 %
20–50 km	0 %	3 %	80 %	16 %
Above 50 km	0 %	1 %	77 %	22 %

We can then use these data and multiply them with environmental intensities for each mode of transport (see Table 4) to obtain data for the baseline scenario. Environmental intensities were calculated using ecoinvent 3.9.

Table 4
Environmental intensities for different modes of transport (own calculations)

	Carbon Footprint	Water Use	Land Use	Mineral Use
	kg CO_2-eq./pkm	m^3/pkm	m^2*a crop eq./pkm	kg Cu-eq./pkm
Walking or cycling[a]	0	0	0	0
Driving	0.233	0.0006	0.0053	0.0066

[a] This is a very simplified approximation, obviously. The environmental impact of cycling could be more relevant in the future with more pedelecs on the road.

The transformed driving patterns were modelled based on data collected in the study participants' schedules. For each daily activity, the persons surveyed had to state the modes of transport involved and the location of the activity. Additionally, we used information from the interviews to refine this information, for example to assess the distance travelled. Some estimates had to be used when exact distances between one place and another remained unclear. However, we were able to find clear indications of greater use of walking and cycling for distances of between one and 5 km (see Table 5). The data show no real difference from the status quo when it comes to distances of less than 1 km (because of sick children, shopping for beverages nearby etc.). Nor did we find any big difference over longer distances (more than 5 km). Long distance daily mobility is often associated with commuting and our data did not indicate that commuting is influenced by the nexus of social practices under investigation. Hence, any deviation from the average mobility in this area cannot be clearly explained and might be due to the small sample and must therefore be excluded. There is also no indication that public transport is affected, so we only discuss the level of walking and cycling.

Table 5
Modal split for short distance mobility affected by the bottom-up neighbourhood initiative

	Walking	Cycling	Driving	Public transport
Under 0.5 km	88 %	5 %	7 %	1 %
0.5–1 km	81 %	4 %	14 %	2 %

(*continued on next page*)

[1] Visit https://www.fao.org/faostat/en/#data/FBS and choose the region 'Western Europe' and the element 'Food supply quantity (kg/capita/yr)', all items and the year 2020.

Table 5 (*continued*)

	Walking	Cycling	Driving	Public transport
1–2 km	70 %	9 %	15 %	6 %
2–5 km	46 %	15 %	25 %	14 %

Travelling

When it comes to travelling, we focused our analysis on flying and distances. Here, we observed a clear trend toward avoiding long distance and intercontinental flights (though financially possible in most cases). Furthermore, intracontinental flights (within Europe) only played a minor role for study participants and were mostly reported in the past, not as planned for future holidays, with one exception. Short trips such as visiting a sister in another city over the weekend, were excluded from the calculations, as we could not observe any connection to the emerging nexus of social practices.

In 2022, planes were the main mode of transport for 27% (18.1 million) of holiday travels starting in Germany (ADAC, 2023). Most destinations were in southern Europe, including Turkey (Destatis, 2022). Overall, intracontinental flights made up ca. 80% of flights from Germany (Destatis, 2023). Given that Germans prefer destinations in southern Europe, we estimate that intracontinental flights are about 1,200 km long. Starting from Dusseldorf, this is about the distance to Mallorca or Rome, yet shorter than flights to most Greek Islands, west Turkey and Portugal and longer than flights to London, Paris and Vienna. For intercontinental flights, we estimate an average distance of 9000 km, which roughly corresponds to a trip to Los Angeles, Cape Town or Bangkok.

A total of 67 million holiday trips (more than five days, regardless of mode of transport) were taken in 2022 by 53 million people (Statista, 2023b). This comes to 8 million intercontinental, 29 million European and 30 million national trips. We can assume that the vast majority of intercontinental trips were made by plane (roughly 7.8 million). 65% of domestic flights are business-related and not relevant for this study (BDL, 2019). Additionally, we must consider that many domestic flights are feeder flights for international trips. However, exact numbers are unknown for holiday trips. We estimate that 75% of inland flights are feeder flights, based on (BDL, 2019), but do not distinguish between business and private flights here. This leaves us with 2.6 million domestic holiday flights. The remaining 7.7 million flights are intracontinental flights. Table 6 summarizes the data for calculating air travel.

Table 6
Overview of holiday flights departing from Germany

	Average distance in pkm	Number of trips per year in million	Overall Distance in million pkm	Annual flight distance per person in km
Domestic	450	2.6	1170	14
European	1200	7.7	9240	110
Intercontinental	9000	7.8	70,200	835

Again, the environmental impacts were calculated using ecoinvent 3.9 with the corresponding processes for short (domestic), medium (European) and long haul (intercontinental) air travel.

Asked about their past and planned holiday destinations and modes of transport, the participants of this study reported only very few flights and a change from flying in the past to other modes of transport for holiday trips now and in the future (we asked for travel activities in 2019 in the survey to get pre-Covid lockdown information and asked for future travel plans after any Covid restrictions in the interviews). It was even reported in the interviews that past plans to take flights were cancelled as they feel it was wrong. One participant talked about maybe making a trip to Japan once in his lifetime, but immediately explained that this goal was a very low priority for him. Another participant reported that they always wanted to visit New Zealand, but now felt that it made no sense as Scandinavia is too similar and much closer. Only one participant stated in an interview that while normally making even longer European trips with his family by train, they had a routine of flying to Israel every 5 years.

As we did not have sufficient information to say that the overall number of trips had changed but only the destinations and modes of transport, we substituted the overall trips from Table 6 with average trips found in our empirical data. On average, the travel distances have been reduced due to slower modes of transport (Croatia instead of Greece, France instead of Spain, northern Italy instead of southern Italy etc.). We reduced international flight trips by 80% as we observed a significant change but wanted to leave room for the rare occasions discussed in the interviews. Domestic flights were off the table for all participants of the study, so we reduced them by 100%. Table 7 shows the substituted travel data. Furthermore, we increased the occupancy level of cars from 1.5 (German average) to 2.5, which is slightly above the occupancy level for general leisure activities (Nobis and Kuhnimhof, 2018) and represents data from the survey.

Table 7 shows how travel practices align in the emerging nexus of social practices.

Table 7
Changed travel distances and modes of transport. Numbers of trips do not show the overall number of holiday trips in Germany, but rather the number of flights previously taken that are now partly substituted.

	Average distance in pkm	Number of trips per year in million	Overall distance in million pkm	Distance per person and year
Car trips	800	7.5	6000	71
Train trips	800	7.5	6000	71
Plane trips Europe	1200	1.5	1848	22
Plane trips intercontinental	9000	1.6	14,040	167

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