Environmental Assessment of Urban Sharing

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This cumulative dissertation contains three pre-published peer-reviewed journal articles:

- Suski, P., Speck, M., Liedtke, C., 2021. Promoting sustainable consumption with LCA – A social practice based perspective. Journal of Cleaner Production 283, 125234. https://doi.org/10.1016/j.jclepro.2020.125234
- Suski, P., Palzkill, A., Speck, M., 2023. Sufficiency in social practices: An underestimated potential for the transformation to a circular economy. Front. Sustain. 3, 1008165. https://doi.org/10.3389/frsus.2022.1008165
- Suski, P., Augenstein, K., Greiff, K., 2024. Life Cycle Assessment of Consumption Patterns – Understanding the links between changing social practices and environmental impacts. Journal of Cleaner Production 477, 143813. https://doi.org/10.1016/j.jclepro.2024.143813

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Tear it up, tear it up

We need the change, we need the change

(Jerry's Kids, 1983)

Abstract

This dissertation addresses the environmental assessment of urban sharing within the framework of the circular economy. In response to severe environmental degradation and the growing urgency for sustainable consumption and production patterns, this work proposes an innovative approach for environmental assessments, combining life cycle assessment (LCA) with theories of social practice. Urban sharing is utilized as a case for reducing resource demand while fostering societal well-being.

Urban sharing is conceptualized here as a social innovation embedded in urban environments, with the potential to reshape material flows and societal relationships. Unlike the more commercially driven sharing economy, urban sharing prioritizes community engagement, sustainability, and sufficiency by encouraging social practices that reduce the need for new goods and services. The dissertation argues that, when properly approached, urban sharing could contribute to the transition from a linear to a circular economy.

The methodological foundation of this work is built on the integration of social practice theory into LCA, allowing for a more nuanced and comprehensive assessment of how consumption patterns drive environmental impacts. Social practices—routine actions like mobility, food consumption, or community activities—are treated as bundles of meanings, competences, and materials that organize everyday life. By assessing these practices, the research introduces a new LCA framework capable of capturing the environmental potential of transformative social phenomena like urban sharing.

The dissertation is structured around three key publications that develop and test this new framework. The first provides a theoretical discussion of LCA's limitations in addressing transformative change and proposes the social practice-based LCA as an alternative. The second explores how urban sharing is embedded in daily life, using empirical research to reveal the social and material contexts in which these practices operate. The third quantifies the environmental impacts of urban sharing activities, applying the newly developed framework to assess their potential for environmental sustainability.

The findings suggest that urban sharing holds significant environmental potential, particularly in reducing material consumption and fostering sustainable lifestyles. However, the research also highlights the importance of embedding environmental assessments in their social contexts to accurately reflect the complexities of human action and societal change. This approach can better inform decision-makers about the pathways toward more sustainable consumption systems.

The dissertation concludes that integrating social practice theory with LCA provides a robust methodological framework for assessing sustainability interventions. By focusing on the practices that drive consumption and environmental impacts, this research offers new insights into how transformative change can be supported and accelerated in the pursuit of a circular economy.

Zusammenfassung

Diese Dissertation befasst sich mit der Umweltbewertung des ‚Urban Sharing' als eine Strategie für eine Kreislaufwirtschaft. Als Reaktion auf die schwerwiegende Umweltzerstörung und die wachsende Dringlichkeit nachhaltiger Konsum- und Produktionsmuster wird in dieser Arbeit ein innovativer Ansatz für Umweltbewertungen vorgeschlagen, der Ökobilanzen mit Theorien sozialen Praktik verbindet. Urban Sharing dient als anschauliches Beispiel für die Verringerung des Ressourcenbedarfs bei gleichzeitiger Förderung des gesellschaftlichen Wohlergehens.

Urban Sharing wird hier als eine in das städtische Umfeld eingebettete soziale Innovation verstanden, die das Potenzial hat, Materialflüsse und gesellschaftliche Beziehungen neu zu gestalten. Im Gegensatz zur eher kommerziell ausgerichteten Sharing Economy legt urban Sharing den Schwerpunkt auf gemeinschaftliches Engagement, Nachhaltigkeit und Suffizienz, indem es soziale Praktiken fördert, die den Bedarf an neuen Gütern und Dienstleistungen reduzieren. In der Dissertation wird argumentiert, dass Urban Sharing zum Übergang von einer linearen Wirtschaft zu einer Kreislaufwirtschaft beitragen kann.

Die methodologische Grundlage dieser Arbeit beruht auf der Integration der Theorie sozialer Praktiken in die Ökobilanz, was eine differenziertere und umfassendere Bewertung der Auswirkungen von Konsummustern auf die Umwelt ermöglicht. Soziale Praktiken - routinemäßige Handlungen wie Mobilität, Lebensmittelkonsum oder Gemeinschaftsaktivitäten - werden als Bündel von Bedeutungen, Kompetenzen und Materialitäten behandelt, die das tägliche Leben organisieren. Durch die Bewertung dieser Praktiken führt die Forschung einen neuen Rahmen für Ökobilanzen ein, der das Umweltpotenzial von transformativen sozialen Phänomenen wie Urban Sharing erfassen kann.

Die Dissertation gliedert sich nach drei Schlüsselpublikationen, die diesen neuen Ansatz der Ökobilanz entwickeln und testen. Die erste bietet eine theoretische Diskussion über die Grenzen der Ökobilanzierung bei der Bewertung transformativen Wandels und schlägt die auf der sozialen Praktik basierende Ökobilanz als Alternative vor. In der zweiten Publikation wird untersucht, wie Urbanes Sharing in das tägliche Leben eingebettet ist, wobei empirische Forschung eingesetzt wird, um die sozialen und materiellen Kontexte aufzuzeigen, in denen diese Praktiken funktionieren. Der dritte Teil quantifiziert die Umweltauswirkungen von Urban Sharing und wendet den neu entwickelten Rahmen an, um deren Nachhaltigkeitspotenzial zu bewerten.

Die Ergebnisse deuten darauf hin, dass Urban Sharing ein erhebliches Umweltpotenzial birgt, insbesondere im Hinblick auf die Reduzierung des Materialverbrauchs und die Förde-

rung nachhaltiger Lebensstile. Die Forschung zeigt jedoch auch, wie wichtig es ist, Umweltbewertungen in ihren sozialen Kontext einzubetten, um die Komplexität menschlichen Handelns und gesellschaftlichen Wandels genau widerzuspiegeln. Dieser Ansatz kann Entscheidungsträger*innen besser über die Wege zu nachhaltigeren Konsumsystemen informieren.

Die Dissertation kommt zu dem Schluss, dass die Integration der Theorien sozialer Praktiken in die Ökobilanzierung ein robustes methodisches Instrument zur Bewertung von Nachhaltigkeitsmaßnahmen darstellt. Durch die Fokussierung auf die Praktiken, die den Konsum und die Umweltauswirkungen bestimmen, bietet diese Forschung neue Einblicke in die Art und Weise, wie transformative Veränderungen im Streben nach einer kreislauffähigen Gesellschaft unterstützt und beschleunigt werden können.

Declaration on publications

Dissertation-relevant publications

This dissertation consists of three peer-reviewed journal articles (Table 1). The third publication is accepted for publication (in press).

Table 1. Dissertation-relevant publications

ID	*Publication*
A	Suski, P., Speck, M., Liedtke, C., 2021. Promoting sustainable consumption with LCA – A social practice based perspective. Journal of Cleaner Production 283, 125234. https://doi.org/10.1016/j.jclepro.2020.125234
B	Suski, P., Palzkill, A., Speck, M., 2023. Sufficiency in social practices: An underestimated potential for the transformation to a circular economy. Front. Sustain. 3, 1008165. https://doi.org/10.3389/frsus.2022.1008165
C	Suski, P., Augenstein, K., Greiff, K., 2024. Life Cycle Assessment of Consumption Patterns – Understanding the links between changing social practices and environmental impacts. Journal of Cleaner Production 477, 143813. https://doi.org/10.1016/j.jclepro.2024.143813

Contributions of doctorate candidate

In all three publications I contributed extensively to the research and publication process. This includes conceptualisation, formulation of research questions, choosing and conducting research methods, data analysis, visualisations, coordination, writing, submission and revisions, organising lectorates and funding for open access. Table 2 provides an overview of my role in the publications.

*Table 2. Contributions of doctorate candidate according to the Contributor Roles Taxonomy (CReDiT; Brand et al., 2015). ✓contribution, - no contribution, * not applicable*

Contributor Role	**Publication**		
	A	**B**	**C**
Conceptualisation	✓	✓	✓
Methodology	✓	✓	✓
Software	*	*	*
Validation	*	-	-
Formal analysis	*	✓	✓
Investigation	✓	✓	✓
Resources	-	-	-
Data Curation	*	✓	✓
Writing – Original Draft	✓	✓	✓
Writing – Review & Editing	✓	✓	✓
Visualisation	✓	✓	*
Supervision	✓	✓	✓
Project administration	✓	✓	✓
Funding acquisition	✓	✓	-

Further publications by doctorate candidate

In addition to the three main articles directly contributing to this dissertation, I have been actively involved in additional research activities that are related to this topic. Three peer-reviewed publications are to name here:

Augenstein, K., Bachmann, B., Egermann, M., Hermelingmeier, V., Hilger, A., Jaeger-Erben, M., Kessler, A., Lam, D.P.M., Palzkill, A., Suski, P., von Wirth, T., 2020. From niche to mainstream: the dilemmas of scaling up sustainable alternatives. GAIA - Ecological Perspectives for Science and Society 29, 143–147. https://doi.org/10.14512/gaia.29.3.3

Pohl, J., Suski, P., Haucke, F., Piontek, F.M., Jäger, M., 2019. Beyond Production—the Relevance of User Decision and Behaviour in LCA, in: Teuteberg, F., Hempel, M., Schebek, L. (Eds.), Progress in Life Cycle Assessment 2018. Springer International Publishing, Cham, pp. 3–19. https://doi.org/10.1007/978-3-030-12266-9_1

Suski, P., Pohl, J., Frick, V., 2020. All you can stream: Investigating the role of user behavior for greenhouse gas intensity of video streaming, in: Proceedings of the 7th International Conference on ICT for Sustainability. Presented at the ICT4S2020: 7th International Conference on ICT for Sustainability, ACM, Bristol United Kingdom, pp. 128–138. https://doi.org/10.1145/3401335.3401709

Contents

1 Introduction

In an era characterized by escalating environmental degradation and the quest for transformative change, the concept of the circular economy has emerged as a pivotal framework and research field (Calisto Friant et al., 2020; Droege et al., 2023; Kirchherr et al., 2023). This paradigm shift challenges conventional linear production and consumption patterns by promoting resource efficiency, waste reduction, and the continual cycling of material flows. While political aspirations to achieve circularity sound very promising in regard to deep transformational change in how we make use of materials (European Commission, 2020), there is an uprising criticism, as actual policies are way less ambitious and instead focus on end-of-life waste management (Calisto Friant et al., 2021; Welch et al., 2017). This is at odds with several attempts to order circularity strategies by their environmental potential, which conclude that strategies that focus on the transformation in our consumption system, like refuse, rethink and reduce, are most favourable (Potting et al., 2017; Reike et al., 2018; Zhang et al., 2022). This dates back to old waste hierarchies, that state that prevention is the best way to handle waste (Zhang et al., 2022).

In order to enrich the discourse and realign the focus from incremental technological change and end-of-life management towards transforming our production and consumption system, a broader perspective of the circular economy transcends the boundaries of material flows alone. It encompasses a profound reimagining of societal values, relationships, and behaviours, with circularity at its core. The proponents of the circular society claim that a transition to circularity is foremost a societal endeavour that is accompanied by deep cultural transformations (Calisto Friant, 2022; Calisto Friant et al., 2023; Jaeger-Erben et al., 2021). A circular society understands, that a fair and sustainable society does not only depend on circling natural resources, but also on circling economic capital (e.g. wealth distribution), political power (e.g. civil participation), knowledge (e.g. access to innovations) and care (e.g. love and affection) (Calisto Friant et al., 2023). Fundamentally, concepts of the circular society provide a clear analysis of the contextualisation or embeddedness of material flows in society and explain that one cannot fix one cycle, e.g. the resource cycle, while neglecting the others. “Excessive accumulation, unsustainable exploitation, lack of effective recovery, lack of sufficient redistribution, or simply neglect can thereby lead to crucial unsustainability problems and even a collapse of planetary functions and societal structures” (Calisto Friant et al., 2023). For academia, political bodies, economic enterprises and civil society, this means that in the pursuit of solutions to establish sustainable circularity, the embeddedness of material cycles in nature and society needs to be recognised, considered in innovation processes and analysed in research projects.

Taking the intertwined and interdependent cycles seriously, means among other things to rethink case studies and interventions, interdisciplinary necessities, and methodologies. For example, for environmental assessments of circular interventions, questions of appropriate system boundaries, units of analysis and interpretation arise (Niero, 2023; Niero et al., 2021). In order to address the issues, this thesis delves into the uncharted territory of urban sharing as a potential example of a circular society and develops solutions to quantify the environmental potential. In contrast to the much debated sharing economy (Agarwal and Steinmetz, 2019), urban sharing is understood as a primarily social innovation in which urban space redistributed and urban life reshaped to establish a paradigm of sharing, participation and care in everyday life, addressing material, political, knowledge, wealth, care and ecosystem cycles (Augenstein et al., 2020). In this work, urban sharing will be illuminated from two sides in an interdisciplinary manner applying a mixed method approach: qualitative social sciences shall help understanding the phenomenon of urban sharing as a societal paradigm and identify how the material cycles are embedded in daily life, while quantitative environmental assessments will answer if there is sufficient environmental potential in urban sharing to further promote it. In doing so, the hypothesis will be tested, that quantitative environmental assessments need to be deeply contextualised in order to provide decision making support for transformative change. Therefore, a brief introduction into sharing conceptualisations in the academic discourse and an overview on the possibilities of utilizing life cycle assessment approaches to conduct environmental assessments of transformational change will be provided next.

1.1 Sharing economy and urban sharing

Sharing is one of those fundamental human activities, that can be found across all cultures and throughout history. It appears in various forms, sharing of tools between professionals or neighbours (Govindan et al., 2020), sharing of knowledge, like from one generation to another by Yucatec midwives or of personal experience in groups of anonymous alcoholics (Lave and Wenger, 1991), sharing things, money and shelter for people in need (Hellmann et al., 2021), but also sharing as a more (cost) efficient way to organise life in a modern platform capitalist society (Bienge et al., 2019; Fernando et al., 2023; Meshulam et al., 2023; Sun et al., 2023). The word ‘sharing’ itself means and meant different things, from dividing and distribution, as in cutting meat in half and give one part to someone else (from the old English ‘scearu’), to a communicative action as in sharing inner thoughts (John, 2017). Sharing can also mean very mundane things, like file sharing or sharing the screen in an online video call.

In sustainability research, sharing became relevant with the rise of digital sharing platforms that appeared under the umbrella term sharing economy in the 2010s. The hypothesis here

is, that intensifying the usage or extending the lifetime of goods by sharing them, the overall resource use can be reduced. Tools are an example that are often used here, as the actual use-time of a hammer or a drilling machine in private households is extremely low compared to its lifetime (Harris et al., 2021). Besides environmental concerns, there are very strong economic arguments to share. As mobility is generally expensive, ride sharing to increase the occupancy rate and car sharing to share the car itself became popular, in practice and in academia (Nansubuga and Kowalkowski, 2021). Here, sharing often times also refers to sharing the costs.

The big hype was quickly followed by a wider disenchantment in the sustainability departments (Celata and Stabrowski, 2022; Scholl et al., 2018). The sharing economy promised a more sustainable, decelerated and simpler life, but instead just further accelerated the growth paradigm (Andreoni, 2020). Strong players with lots of venture capital flooded the market in a fight for monopolies and no regard of the waste of resources (Haas, 2017). When access over ownership (Belk, 2007) is only used to gain more access to more things, then there is not much in it for sustainability. The old Jevon's Paradox, that in capitalist societies more efficient use of resources always leads to an increased demand of such resources, again seems to hold true (Jevons, 1865). The positive connotated sharing economy got a new negative connotated categorization: platform capitalism (Celata and Stabrowski, 2022; Srnicek, 2017). Here, sharing only aims for an accumulation of capital, instead of reduced consumption of resources. Non-profit sharing, also considered 'true sharing' by Belk (2014), was replaced by for-profit sharing, or 'pseudo-sharing', leading to market growth and hence, increased environmental pressure (Frenken and Schor, 2017). There are also signs that platform based for-profit sharing has negative impacts on social cohesion, as the economization of idle things raises opportunity costs, leading to personal disadvantages of freely lending things to family and friends (Frenken and Schor, 2017).

Meanwhile, quantitative environmental assessments of sharing economy activities, struggle to grasp sharing in a comprehensive manner. Bienge et al. (2019) show in their assessment of 20 sharing economy activities that there is environmental potential, but also state, that any kind of rebound effects, and hence Jevon's Paradox, were neglected. Do second hand clothing markets lead to reduced demand for resources or a faster fashion culture? Simply dividing the carbon footprint by two for second hand jeans is not sufficient. The wording of environmental potential must be taken seriously here: there is a theoretical potential to save resources by sharing cloths, cars etc. but that does not mean, that we actually raise any of those potentials by current activities. Piontek et al. (2020) provide more insight into clothing rental services by conducting a simplified LCA and concluded that the environmental potential very much depends on specifics of the business model. Often times rented clothing show

higher environmental impacts compared to conventionally owned garments. However, cultural aspects and rebound effects of fashion are not considered. In order to include the human aspect in sharing, Fernando et al. (2023) provide a dynamic LCA on shared mobility including consumer preferences, which however still misses the embeddedness of the 'consumers' in social contexts.

Aware of the problems with the sharing economy, there are many projects and stakeholders, that also inherit sharing, but approach the issue differently. Collaboration, community and commons are important concepts that are put in the centre in contrast to business models and a growth mindset. The general idea is similar to the promise of the sharing economy: making sustainable use of underutilized assets (Frenken and Schor, 2017; Mi and Coffman, 2019). However, this time human relationships, communities, are seen not only as a necessity of sharing or something that can be substituted by digital platforms, but are an end in themselves (Celata and Stabrowski, 2022; Richardson, 2015).

Sharing is here also understood as an invitation for participation, to the co-production of the life around sharing. While sharing can generally be based on virtual platforms (Zhu and Marjanovic, 2021), here the definition is further narrowed down to an urban environment, and more specifically neighbourhoods. As research shows that third places can play vital roles in enabling sustainable consumption and increase quality of life in the neighbourhood, some emphasis will be put on the analysis of such places (Goosen and Cilliers, 2020; Jeffres et al., 2009; Nasehi et al., 2023). Third places describe (semi-)public places where considerable amount of time can be spent and that are outside of home and the workplace (Jeffres et al., 2009). They can be rather mono-functional like a (community) garden, a library or a pub, or multifunctional like community hubs. As a living sharing society needs to be organized somehow (Jaeger-Erben et al., 2015), multifunctional community hubs will be part of the analysis of an urban sharing society and its environmental potential. For this community-based sharing, that is not defined by specific activities, but can be considered as a paradigm of how to organise material things and life in local societies, the term urban sharing will be used.

The idea of environmentally assessing urban sharing is the hypothesis that urban sharing shifts its core desire from blind accumulation of goods to meaningful experiences in life and care for society, which resembles a more resonant and sufficiency-oriented society.

There are many parallels to the discourse on the circular society (Calisto Friant et al., 2023; Jaeger-Erben et al., 2021) that also distinguishes itself from the reductionist reality of the circular economy by providing a broader conception of circularity, that includes cultural and social dimensions. Greene et al. (2023) show in their analysis on the circular economy at

home, how intertwined social and material dynamics are and the analysis of such is necessary in order to analyse and establish sustainable circular consumption in everyday life. Both ideas, circular society and urban sharing, aim at deeper, more structural transformations than its economic conceptualised counterparts, while shifting the focus to questions of good life and participation instead of economic growth. Hence, urban sharing can be understood as one crucial part of a circular society, with a common goal: reduced resource demand by achieving a better life for all.

In order to have an understanding of whether or not such urban sharing is capable of reducing resource demand and corresponding environmental impacts, a quantitative environmental impact assessment is necessary.

1.2 Life Cycle Assessment and transformative change

Life cycle assessment (LCA) is a method that allows quantitative environmental assessments along supply chains. The aim of LCA is to support decision-making based on a comprehensive analysis in order to avoid problem shifting. Problem shifting occurs when environmental impacts in one part of the supply chain can be reduced by increasing the impact in another part of the supply chain. An example of this is the reduction of carbon emissions while driving an electric car (compared to cars with internal combustion engines), but the emission in the production phase of that car increase due to the large batteries (European Environment Agency, 2018). What is preferable when buying a new car and wanting to limit the environmental impact? An LCA can help here. The decision support can occur in various areas: product comparisons, environmental product design, development of public policies that are of environmental relevance, strategic planning in businesses or marketing etc. (ISO, 2006).

While LCA works relatively well on a product level (goods or services), this perspective has its limitations to promote sustainability. As already discussed above, transformative change is needed and proclaimed by many stakeholders (Brand and Wissen, 2017; Lorek and Spangenberg, 2014; Parrique et al., 2019; Schneidewind and Augenstein, 2016). Transformation, again, refers to “[l]arge-scale societal change processes” (Hölscher et al., 2018). The underlying critique is, that there is no empirical evidence that technology-centred green growth approaches, e.g. found in the European Green Deal, actually leads to absolute decoupling of environmental impacts from economic growth, or only too slowly (Haberl et al., 2020; Lorek and Spangenberg, 2014; Parrique et al., 2019). While transformation ultimately aims at reduced resource extraction and emissions, which is generally also the motivation for conducting LCA, it is not so much the question of very specific products and their supply chains that need to be optimised. Instead, whole areas of consumption and production are being addressed and reshaped (Lorek and Spangenberg, 2014). In such cases, comprehensiveness is not achieved by only looking at supply chains, but by analysing how those are embedded in

society. Coming back to the electric car example: transformative change means that it is not only about petrol vs. electricity, but about how we want to be mobile as a society to meet the demands of a sustainable society. This includes for example aspects of built infrastructure for various modes of transportation (Jarašūnienė and Česnulaitis, 2023), rethinking urban planning paradigms such as the charta of Athens (Stouten, 2012), and digital solutions that substitute for mobility, such as teleworking (van Lier et al., 2014; Curtis et al., 2025).

According the ISO 14040, LCA consists of four main phases: 1) goal and scope definition, 2) inventory analysis, 3) impact assessment and 4) interpretation. The goal and scope phase includes the formulation of research questions, defining system boundaries and functional units. Overall, it should include a clear analysis of the decisions that are being made in the context of analysis and which shall be supported by that LCA. However, Zamagni et al. (2012) have analysed in their literature review on the current state of LCA, that this goal and scope phase is mostly neglected in LCA research as this phase is being considered trivial. The broader context and how change can come about is mostly left out.

In recent years a new trend in LCA research could be observed, where more vivid and rigorous discussions about the comprehension of the phenomenon under investigation are held. For further discussions, I want to distinguish between two different kinds of approaches, inclusion of higher order effects (including rebound effects) and combination with social theories (especially theories of social practice).

1.2.1 LCA and higher order effects

Higher order effects describe effects in production and consumption patterns that cannot be grasped with supply chain logics and that are sometimes not even part of the supply chains under investigation (Hilty and Aebischer, 2015; Pohl et al., 2019). Considering higher order effects means, that the LCA practitioners understand that there is some sort of embeddedness (economic, social or behavioural) of the product that is being environmentally assessed. Some sorts of higher order effects are then being used in studies on topics that are being understood as more transformative, like digitalisation (Pohl, 2022), Sharing Economy (Meshulam et al., 2023), transport innovations (Font Vivanco et al., 2015). Rebound effects, a specific kind of higher order effects, describe the phenomenon that a positive environmental effect of an intervention is being countered by unintended and negative environmental side effects. A typical example is that of a more efficient car engine that reduces petrol demand, which is countered by heavier cars and more car mobility that increases petrol demand (Berkhout et al., 2000). In LCA, rebound effects are often regarded in forms of economic or time use elasticities (Buhl and Acosta, 2016a, 2016b; Font Vivanco et al., 2015). Underneath such calculations lies a neo-classical understanding of economics and behaviour (rationality and optimisation of the consumer behaviour, see Berkhout et al., 2000). While

the research on rebound effects often distinguishes between economic and psychological rebound effects (Reimers et al., 2021), LCA practitioners primarily focus on economic rebound effects in empirical studies, which is easier to quantify in regard to material flows (Font Vivanco and van der Voet, 2014). Another differentiation in rebound effects is direct and indirect effects, the former describing the increased use or production of the same (more efficient cars lead to more car travelling), the latter describing increased production or consumption of other things (e. g. savings from more efficient cars leads to more spending on holiday flights etc.). As Font Vivanco and van der Voet (2014) show in their literature review on LCA and rebound effects there are additional ways to differentiate rebound effects. They differentiate between micro and macro effects as well as short-term and long-term effects. One challenge is, that there is no general rule which kinds of rebound effects are to be included in LCA studies to comprehensively assess change.

Other higher order effects that are discussed in regard to environmentalism for example are induction effects (Hilty and Aebischer, 2015; Pohl et al., 2019), macroeconomic effects (Hilty and Aebischer, 2015; Miller and Keoleian, 2015) and spill-over effects (Greene et al., 2024). Again, there is no rule or common understanding about which sorts of higher order effects are to be included, and how this is done. Induction effects, which describe the increased purchase of devices due to technological constellations, e.g. smart heating which aims at decreasing energy demand is often accompanied by other smart home devices which increase energy demand, stick out here, as primary data is gathered to describe the actual change in consumption by this technological innovation (Pohl et al., 2021).

It can be concluded that the inclusion of higher order effects in LCA leads to important discussions on the comprehensiveness and fields of applications of LCA and, as a result, on the general value of LCA results. However, higher order effects do not provide any real solution for incomprehensiveness to assess transformational change as it does not come with a coherent understanding of social change (Galvin and Gubernat, 2016; Sonnberger and Gross, 2018). Empirical studies and theoretical discussions rather provide a patchwork of possible effects that assume that different things might occur. Each additional identified and described higher order effect adds another epicycle to a flawed model. Economic rebound effects usually work with income elasticities, which means that change only results in statistical re-spending of money (Buhl and Acosta, 2016b). The same is true for time rebound effects that assume change will only lead to statistical re-spending of time capacities (Buhl and Acosta, 2016a). However, as transformation aims at changing the direction of society, how can we use past data to calculate the effects of (potentially) transformational interventions? How do we analyse the essence of a given phenomenon, like urban sharing, to decide whether it is an economic, temporal or psychological question? Which higher order effects

should I pick to assess sharing as a paradigm of urban living? Overall, many of these approaches understand that the subject of analysis is contextualised, embedded in social and material structures. However, they aim to include additional numbers with limited understanding of the context of their subject.

This excursus on higher order effects shows that they might be useful in covering specific effects of small changes (e.g. increased energy efficiency of electric devices), but are not able to comprehensively grasp transformative changes. Transformative change does not follow existing rules that are described for example by income elasticities, but change the rules of social order itself. Hence, for a comprehensive environmental assessment of urban sharing, a different approach is necessary, that does not presuppose specific social effects, but comprehensively analyses its embeddedness in society. This means that urban sharing and its impact on social life needs to be understood, which is a question for qualitative empirical social sciences (Galvin and Gubernat, 2016; Sonnberger and Gross, 2018).

1.2.2 LCA and social theories

A second and much smaller strain of LCA research recently appeared that aims at connecting LCA to social theories to assess transformative change (Ellsworth-Krebs et al., 2023; Niero et al., 2021; Speck and Hasselkuss, 2015). Social theories explain how social order and social change fundamentally emerges. They provide descriptions on how and why societies are able to exist and what the fundamental elements of society are. Social theories are general and abstract thoughts about social matters (Joas and Knöbl, 2014). As such and historically they have nothing directly to do with environmental assessments or sustainability. However, as transformative change is change that addresses the social fabrics, it is only logical that sustainability researchers and especially research on sustainable consumption want to learn from social theories and adjust their research accordingly (Warde, 2022). As social theories are describing the very basics of human society, they inherit strong ontological positions and can be distinguished by them. Hence, in order to understand how the research object is embedded in society, an explicit reflection on the ontological position of the research is necessary, before starting empirical analysis (Geels, 2010). This basic understanding of social embeddedness is a starting point for developing a methodological framework for comprehensive environmental assessments. To provide an overview to this field, three basic families of social theories based on their ontological positions can be distinguished. Those basic positions are important to know when looking for an access and a language to describe and understand urban sharing and how it is embedded in daily life. A more detailed discussion on social practice theories can be found in chapter 2.

1) Individualism

Ontological individualism "holds that all social entities are reducible without remainder to [..] compounds of individuals. On this account, social entities are nothing but ensembles of individuals in various relations to one another." (Little, 1991, p. 183).

Individualism, which dates back at least to Hobbes' Leviathan in 1651, is often implicitly involved in LCA studies. This is always the case when LCA results shall be used to inform individuals on the environmental performance of products, so that they can make informed and rational choices. This is especially the case when broader household studies are used, often times in digital tools like carbon footprint calculators, to inform people on their "individual" environmental, carbon or material footprint (Buhl et al., 2017; Greiff et al., 2016). However, these studies often miss an explicit reflection on their ontological position.

Rebound effects, whether psychological like moral licensing or microeconomic that address rational spending behaviour, are also based on individualist understandings of the world. Every study that focuses on behaviour change is usually based on ontological individualism, whether it be explicit or not. Polizzi di Sorrentino et al. (2016) provide an elaborate account of behaviour theories that can be useful in LCA. Suski et al. (2020) have shown how the analysis of video streaming behaviour can be used to model the use phase in an LCA and identify determinants of environmentally relevant video streaming behaviour. Fernando et al. (2023) use consumer preferences as a viable variable to conduct dynamic LCA.

The question of agency and the lack of understanding of embeddedness of action in social systems is a general critique on such individualist accounts (Kennedy et al., 2015; Shove, 2010; Spurling et al., 2013). For sustainable development in general, but also for LCA specifically, the question occurs, who is responsible for specific actions and the change of that (Mock, 2020). As LCA shall help making environmental decisions, LCA practitioners have to question who is actually in a position to make relevant decision and how could those decisions look like?

A very special and recently popular social theory that is somewhat part of the family of ontological individualism is the actor-network theory (Callon, 1986). This theory is special in the sense that the actors do not need to be humans, but can be, as Latour (1996) simply puts it, non-human and non-individual. The additional focus on the network of actors, also make it seem more embedded in social structures. Niero et al. (2021) and Niero (2023) provide discussions on how to connect LCA to actor network theory in order to address unintended side-effects by mapping actor networks.

2) Holism (nonindividualism)

While theories of individualism are relatively homogenous, holism, or nonindividualism, is a very heterogenous family of social theories, which only have in common that they are in opposition to individualism. The basic idea of ontological holism is that social phenomena as such exist, as sui generis. This is in opposition to individualism which says that every phenomenon can be reduced to individuals and their properties. Durkheim explains here, that social phenomena cannot be reduced to individuals, as the properties of complex systems cannot be reduced to properties of its parts. "Yet what is so readily deemed unacceptable for social facts is freely admitted for other domains of nature. Whenever elements of any kind combine, by virtue of this combination they give rise to new phenomena. One is therefore forced to conceive of these phenomena as residing, not in the elements, but in the entity formed by the union of these elements." (Durkheim, 1982, p. 39). This means that "if, as is granted to us, the synthesis *sui generis*, which constitutes every society, gives rise to new phenomena, different from those which occur in consciousnesses in isolation, one is forced to admit that these specific facts reside in the society itself that produces them and not in its parts" (Durkheim, 1982, p. 39).

Societal wholisms (this time with a w), like Luhmanns' system theory, state that society consists of social systems like economy, politics, art, media, law etc. that communicate with each other (which is not human communication) and consist of various subsystems. Each "system possesses a distinct functional rationality and constructs a realm of differentiated functional meaning, which is itself entirely self-referential, self-reproductive or self-organizing" (Thornhill, 2013, p. 569). In this autopoietic regard, societal wholisms are the complete opposite of individualism, as they say that each subsystem's properties are to some extend dependent on the properties and dynamics of the main system (and not the other way around). Individuals are then positioned in such systems, and their desires, cognition etc. are derived from these positions. Or as Marx puts it, they are the carriers (Träger) of the whole (Marx, 1867).

As LCA is rooted in product level thinking, there are practical barriers on the methodological level to make any connections to such broad societal systems. Other methods, like environmentally extended input-output analyses (Vita et al., 2019) and concepts like social metabolism (Haberl et al., 2021) might be more suitable to some ontological systems thinking.

There are various other forms of nonindividualism, like structuralism, interactionism and theories of process and becoming that are not known to have been discussed in regard to LCA and therefore they shall not be discussed here any further.

3) Practice Theories

Theories of social practice are another group of social theories that are non-individualist, but that I want to discuss separately, as they are also distinct to holism and the idea of systems. In practice theories, social practices are central to social life and social analysis, which means that there is a distinct ontological position that does not place individuals nor systems in its focus. But what are social practices? Social practices can be described in the most basic fashion as organized activities. While individualists understand activities as an expression of the individual who perform them, practice theorist recognize that there are organizing structures that make the activities the way they are and that this process of organization does not refer back to the individuals that are carrying them out (Schatzki, 1996). This organizing, which is a societal endeavour, is what makes social practices social, even when carried in solitude (Reckwitz, 2002). Whether social practices are to be understood as routines (Reckwitz, 2002; Shove et al., 2012) or as normative manifold versions of actions (Schatzki, 1996), there is a notion of recursive societal development of practices, and no isolated individual action. What actually organizes social practices is a discussion between several practice theorists. Giddens (1984) speaks of sets of rules and resources that organize social practices. Reckwitz (2002) as well as Shove et al. (2012) describe blocks or bundles of things, of bodily movement, competences, meanings, stuff/materials etc. that make up social practices. Schatzki (1996) does not see materials as part of social practices, but describes social practices as being embedded in a material world. He rather stresses teleoaffectivity as the central organizing element of social practices. What these theorists have in common is the profound understanding of the material world as an aspect of social life[1] (Giddens distinguishes between authoritative (status) and allocative resources (economic resources and material objects), Giddens, 1984). This is central to the goal of conducting meaningful LCA, which is based on the analysis of material flows through our society, and the different, rather philosophical accounts of the material world, are not necessarily relevant for the empirical studies and assessments.

The fact that social practices describe every kind of ordinary activity, from driving a car to unloading intercontinental freighters in ports, makes this conceptualization of the social

[1] There are other social practice theorists, that neglect materials in their works. This, however, should not be overestimated, as there are different backgrounds that lead to such conceptions. For example, Lave and Wenger (1991) provide extensive practice theoretical accounts of learning and teaching without conceptualizing materials. While this is relevant work in their field, it is ok that their theoretical conceptions of social practices are of less use for environmental assessments.

world quite appealing to LCA practitioners. Niero et al. (2021) discuss, besides actor-network theories, the possibilities of practice theoretical accounts to conduct comprehensive LCA of the circular economy in order to account for higher order effects. Speck and Hasselkuss (2015) provide environmental calculations of sufficiency-oriented social practices. Ellsworth-Krebs et al. (2023) use practice theoretical understandings of the world to discuss the results of their comparative LCA and what they mean in regard to the decision-making context and relevant stakeholders.

There is another central ontological aspect of social practices, that make them so interesting for the goal of environmentally assessing transformative change, and urban sharing specifically, and this is the flat ontology (Schatzki, 2016). Flat ontology means, that there is no structural hierarchy in the world, but only social practices that lay flat next to each other. Every connotation of micro and macro, of niche and regime is obsolete. While this seems irrelevant for the cause of conducting LCA it has two relevant implications. First, the flat ontology also means that the social practices are directly connected to each other, without an intermediary, like a system or individual. Social practices exist in nexus of social practices, or overall speaking, there is a plenum of social practices. And the second, rather obvious implication is, that if we are generally able to environmentally assess social practices, there are no (theoretical) limits in analysis, as there are no other structured entities that elude themselves from our assessment, no abstract systems or social landscapes that need to be quantified, just social practices. For Giddens, there are no structures outside of social practices, but social practices are the structures themselves (Giddens, 1979).

This idea of social practices that exist in nexus allows for a comprehensive understanding of what is described in other studies as rebound effects or higher order effects (Niero et al., 2021; Sonnberger and Gross, 2018). In this regard, social practice theories offer exactly what was criticized above about higher order effects in LCA: a comprehensive understanding of society and its intertwined dependencies instead of a focused view on single effects.

This short overview on social theories only introduced some basic conceptions and arguments that are relevant for conducting an LCA. It does not provide elaborate discussions on what is the best social theory in general. Instead, it shows the importance of getting informed in social theories and reflect the implications of one's ontological position, when LCA shall be used in a process to transform society, especially in cases of social innovations. Having a clear and general understanding of how society persists and changes enables researchers setting up empirical studies that aim for transformational change. This dissertation will further explore the possibilities and positive effects of conducting an LCA in a social practice theory informed manner, by theorizing its potential role in LCA in chapter 2 as part of the

methodological framework, called social practice based LCA and in chapter 4 in an empirical study where the nexus of urban sharing will be environmentally assessed.

1.3 Research questions and structure

The overall objective of this dissertation is a methodological development that allows life cycle assessments to address, and hence support, transformative change, by recognising the social embeddedness of the object of analysis. In showing a way to understand the research object from a social science perspective, the problem with currently available LCA approaches to complex impacts (e.g. rebound effects) is addressed, in which the lack of understanding of the context of analysis sometimes leads to arbitrary choices in problem definition, system boundaries and data collection. To address this research gap the following hypothesis will be tested:

The integration of social practice theory with life cycle assessment (LCA) will lead to a more comprehensive understanding of the environmental impacts of transformative social phenomena, such as urban sharing, by accounting for both the supply chain logics inherent in LCA and the embeddedness of social practices in daily life. Specifically, this integrated framework will reveal environmental impacts that are otherwise overlooked in traditional LCA approaches, which focus primarily on technical and material aspects.

Urban sharing shall serve as an empirical case to test the effectiveness of the methodological development and show in how far new paths to environmental assessments open up new perspectives on sustainable development. In order to test the hypothesis, the following research questions will be answered throughout this dissertation:

RQ1: How can LCA make use of theories of social practice for comprehensive environmental assessments?

RQ2: How is urban sharing embedded in daily life?

RQ3: What is the environmental potential of urban sharing?

Answering RQ1 leads to a methodological framework that addresses gaps in current LCA models, by adding another dimension of comprehensiveness to LCA, which is the social embeddedness. Theories of social practice will be used to provide a coherent and comprehensive understanding of the social. The provision of a methodological framework results in clarity regarding the interplay of research methods that aim for understanding (qualitative methods) and explaining or assessing (quantitative methods) the research object. The results for RQ2 will provide a detailed understanding of urban sharing, based on a study in the Arrenberg neighbourhood in Wuppertal, Germany, and how it is connected to other social practices in a nexus of social practices. Answering RQ3 will be based on the methodological

framework (RQ1) and the understanding of urban sharing (RQ2) as inputs for the goal and scope phase, specifically the system boundaries, as the first step of the LCA of urban sharing. The quantitative environmental assessment will provide a potential for reducing environmental pressure due to the emerging social practice of urban sharing. The results will ultimately show the added value of theories of social practice in LCA.

The main body of this dissertation consists of three chapters in the form of three peer-reviewed publications, that subsequently answer the research questions. The presentation of the publications will be followed by a synthesis and conclusion. Figure 1 provides an overview on the structure of this thesis.

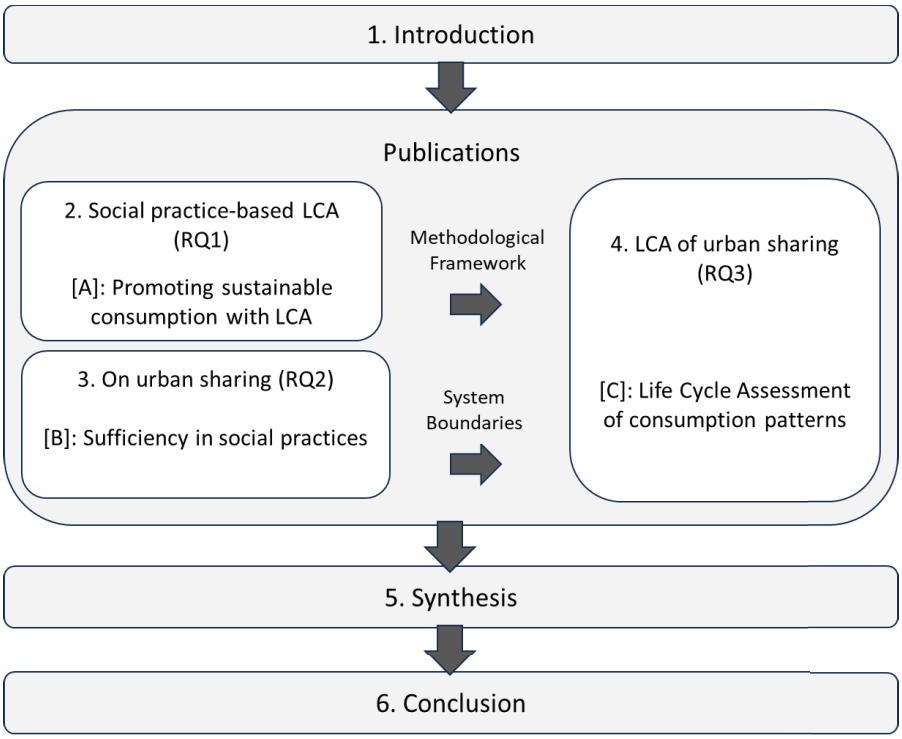

Figure 1: Structure of the dissertation; i.: chapters; [j] publications according to Table 1

2 Publication A: Social practice-based LCA

Suski, P., Speck, M., Liedtke, C., 2021. Promoting sustainable consumption with LCA – A social practice based perspective. *Journal of Cleaner Production 283*, 125234. https://doi.org/10.1016/j.jclepro.2020.125234

To achieve the first task and based on a discussion of currently available LCA methodologies regarding their potential to assess transformative change in the consumption system, a new LCA approach that is based on theories of social practice is developed. The proposed mixed-method methodology is able to comprehensively assess social phenomena and their effect on the environment, by shifting the focus from products and their value chains to social practices and the nexuses they are embedded in. Social practices are understood as bundles of things, of meanings, competences and materials, which represent the routinized actions in daily life (e.g. driving). As the consumption of resources is an integral part of social practices, a combination of qualitative methods to identify social practices and how they are connected to each other, and quantitative methods to environmentally assess consumed resources is suggested. In this way, LCA is based on a profound understanding of the social world, which increases its relevance, by being able to formulate better questions, identify environmentally relevant system boundaries, collect data that represents actual change and address relevant stakeholders. Empirical studies are necessary to validate this social practice based LCA.

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Promoting sustainable consumption with LCA – A social practice based perspective

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ABSTRACT

Quantitative environmental assessments are crucial in working effectively towards sustainable production and consumption patterns. Over the last decades, life cycle assessments (LCA) have been established as a viable means of measuring the environmental impacts of products along the supply chain. In regard to user and consumption patterns, however, methodological weaknesses have been reported and, several attempts have been made to improve LCA accordingly, for example, by including higher order effects and behavioural science support. In a discussion of such approaches, we show that there has been no explicit attention to the concepts of consumption, often leading to product-centred assessments. We introduce social practice theories in order to make consumption patterns accessible to LCA. Social practices are routinised actions comprising interconnected elements (materials, competences, and meanings), which make them conceivable as one entity (e.g. cooking). Because most social practices include some sort of consumption (materials, energy, air), we were able to develop a framework which links social practices to the life cycle inventory of LCA. The proposed framework provides a new perspective of quantitative environmental assessments by switching the focus from products or users to social practices. Accordingly, we see the opportunity in overcoming the reductionist view that people are just users of products, and instead we see them as practitioners in social practises. This change could enable new methods of interdisciplinary research on consumption, integrating intend-oriented social sciences and impact-oriented assessments. However, the framework requires further revision and, especially, empirical validation.

1. Introduction

Global efforts against environmental degradation are inadequate. National and international programmes for decarbonisation consistently fail to keep global warming below 1.5 °C (New Climate Institute and Climate Analytics, 2019). Global resource extraction and carbon emissions are still increasing, demanding increased action (Bringezu and Bleischwitz, 2009; IPCC, 2018; IRP, 2019). The Sustainable Development Goals (SDG) of the United Nations address environmental conservation on a broad spectrum but most consistently in SDG 12, for which the goal is a 'fundamental shift towards sustainable consumption and production patterns' to reduce global resource extraction (United Nations, 2019). The combined notion of consumption and production is found again in target 4 of SDG 8, calling for 'global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation'. In the field of circular economy, we can find quite similar notions in the 10 R-Imperatives, which aim at resource use reduction by changed consumption (e.g. found in R0 - refuse, R1 – reduce and R2 - resell/reuse) and production patterns (e.g. found in R5 – remanufacture and R7 – recycle materials) (Reike et al., 2018). Here, the *power of the inner circle* describes the importance of reducing the overall material base in our society instead of just focusing on end of pipe strategies such as recycling (Ellen MacArthur Foundation, 2014). Strategies that are closer to the consumer are reported to show higher resource saving potentials (Reike et al., 2018).

To measure success (and failure), tools are necessary that assess ongoing attempts to decrease anthropogenic environmental pressure. A widely used and acknowledged tool for quantitative environmental assessments to help decision-making processes in, for example, production, design, and politics, is the life cycle

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assessment (LCA). The Better Regulation Toolbox from the European Commission states that LCA is suited to provide holistic, integrated environmental assessments that improve the development of national and international policies (European Commission, 2015).

Because LCA originates in the supply chain management of products (Guinée et al., 2011), most studies and discussions focus on products and production (Bieser and Hilty, 2018; Finnveden et al., 2009; Font Vivanco and Van der Voet, 2014; Guinée et al., 2011; Henriksson et al., 2015; Liedtke et al., 2014; Pohl et al., 2019a). The term 'life cycle' refers to supply chains of products and does not consider consumption patterns. Most studies use a product as a research object, in form of a good, service, or product service system (Bieser and Hilty, 2018; Hilty and Aebischer, 2015; Mont, 2004; Pohl et al., 2019a; Pouri and Hilty, 2020, 2018).

However, studies such as *1.5 Degree Lifestyles* indicate that strategically developed lifestyles or consumption patterns also show high potential for reducing greenhouse gas emissions, for example, by adopting a vegan diet and reducing living space and motorised mobility (Institute for Global Environmental Strategies; Aalto University; D-mat ltd, 2019). Speck (2016), Greiff et al. (2017) and Buhl et al. (2019b) demonstrate substantial differences in a household's environmental impact, even within socioeconomic groups, depending on the individual lifestyles. However, those studies are based on conventional product-focused LCA because they add products up to baskets of products (Sala et al., 2019) and, correspondingly, add up their environmental impacts. This approach of assessing what individuals *have* is at odds with many theoretical and qualitative empirical studies on sustainable consumption, which focus on what individuals *do* (Røpke, 2009; Warde, 2005; Welch and Warde, 2015). Accordingly, in this article, we attempt to answer the following question: How can LCA be further developed to be able to fully understand environmentally relevant changes in consumption patterns?

Putting effort into such fundamental questions on the goal of LCA studies aligns with the findings of Zamagni et al. (2012). They concluded in a literature review that many LCA studies do not clarify their aim. Implying that consumption is addressed, whereas only assessing consumer products might lead to wrong conclusions. Bienge et al. (2019) raised awareness in this regard in their environmental assessment of forms of collaborative consumption. They calculated resource efficiency potentials of, for example, carsharing, but ultimately argued that because of neglecting indirect effects (rebound effects), no adequate picture of consumption changes was drawn, and the true resource efficiency potentials remain hidden. They suggested further research to deliver a more holistic environmental assessment focusing on changing consumption patterns.

Several studies highlight the use phase of products and the necessity for support from behavioural science (Daae and Boks, 2015; Pohl et al., 2019b; Polizzi di Sorrentino et al., 2016; Suski et al., 2020). This focus is derived from the assumption that user behaviour is relevant to environmental impact because of the high variance of product application (Achachlouei and Moberg, 2015; Jönsson, 1999; Liedtke et al., 2014; Shahmohammadi et al., 2018).

Those studies are focused on the use phase where the products, not the user itself or the consumption phase, are identified as the (potential) research object. This method is problematic because effects can be identified which do not fit into the logic of a supply chain because they appear outside the studied chain (and thus are not part of the life cycle). Multiple studies summarise this as higher order effects (Hilty and Aebischer, 2015; Pohl et al., 2019a; Pouri and Hilty, 2018), and others focus specifically on rebound effects (Buhl, 2014; Buhl et al., 2017; Font Vivanco et al., 2015; Font Vivanco and van der Voet, 2014). Such studies are pivotal to exposing LCA's inadequacy in finding pathways to absolute resource extraction and emission reductions (compared to relative reductions on the product level). What is questionable, however, is whether the same approaches (including specific higher order effects) are the best way of tackling these issues.

The aforementioned studies on higher order effects and behavioural science seem to share the idea that focusing on production alone may be insufficient to achieve the sustainability goals; further, this implies a demand in the inclusion of consumption in the field of quantitative environmental assessments on the micro level.

We state that the consumption perspective discussed in this article intends to increase the range of topics that can be assessed using LCA.

The background of this article is an attempt to environmentally assess urban sharing activities. Although many recent LCA studies focus on the sharing economy (Bienge et al., 2019; Gossen et al., 2019; Neef et al., 2019; Piontek et al., 2019; Pouri and Hilty, 2020), few studies investigate the effects in the consumption patterns of individuals. Notably, this article does not include an LCA but proposes a framework for an LCA on consumption that shall be used subsequently. When useful, we use the example of urban gardening throughout this text. We expect this sharing activity to have a low environmental potential from a production point of view (compared to other agricultural production pathways) but a higher environmental potential when assessing the associated consumption patterns (compared to other leisure activities or corresponding lifestyles).

Thus, a central question we must address, if we generally want to address how LCA can be further developed is: What exactly is consumption in this context? In this article, we first discuss the approaches in LCA research, which address topics from the field of consumption and discuss why they are unsuitable for holistic assessments of consumption. Next, we present the concept of social practices that help us understand and model consumption in a holistic manner; building on that, we introduce a new social practice based framework for modelling consumption in LCA and highlight the need for conducting an appropriate assessment. Finally, we draw conclusions from the development of the new framework and provide an outlook for further research.

2. Sustainable consumption in current LCA models

The development of LCA might be considered an easy task in one regard: It always aligns with other disciplines and methods (e.g. mechanical engineering to describe material and energy flows in the production system or economics in the case of consequential LCA). Thus, to develop LCA to raise questions of consumption, reviewing concepts in other disciplines is an approach used by several scientists. Brandão and Weidema (2014) show that concepts from the field of economics can be used for LCA. The concept of consequential LCA uses economic concepts such as marginal supply and demand (Earles and Halog, 2011; Guinée et al., 2018; Weidema, 2003, 1993). In the articles of consequential LCA, consumption is understood as an economic transaction that results in market activity. Discussions and developments on the consequential approach are an important contribution to the field of LCA. However, reducing consumption to the act of buying is superficial compared to a holistic, integrated approach to assess sustainable consumption, or as Warde (2005, p. 137) states: 'Consumption cannot be restricted to, nor defined by, market exchange'.

Font Vivanco and Van der Voet (2014) show in their literature review on rebound effects and LCA that a part of rebound research is including consumer behaviour in LCA. They assess consumer behaviour mostly from microeconomic perspectives and by

analysing financial transactions. However, Font Vivanco and Van der Voet also point out that some research teams oppose such traditional economic theories of choice. Hofstetter and Madjar (2003) argue that other factors can trigger changes in consumer behaviour and, hence, rebound effects such as time, information, skills, or physical space. Furthermore, they explain that consumption behaviour is not primarily driven by such microeconomic utilities but by quality of life, happiness, and subjective well-being. Unfortunately, this aspect of Font Vivanco and Van der Voet's literature review is disregarded in their later work on a model to assess rebound effects of eco-innovations (Font Vivanco et al., 2015). Here, they only use statistical expenditure behaviour (income elasticity) to calculate rebound effects—with nonetheless notable results.

We now want to focus on three approaches that implicitly or explicitly address issues of consumption in LCA, namely the use phase modelling, rebound effects and household studies. In these thematic clusters, aspects of doings and consumption often enter the LCA.

2.1. Use phase modelling

Polizzi di Sorrentino et al. (2016) introduce basic concepts of behavioural science that are useful for describing the use phase of products in life cycle inventory models. They elaborate that traditionally it was and still is expected that consumers behave completely rational and make decisions based on weighted costs and benefits. As this is neither state-of-the-art science nor helpful in gathering data on behaviour for LCA, new concepts emerged that include attitudes, beliefs, and situational conditions as determinants for expected behaviour. For explanations on how to gather data on behaviour for use phase modelling, see Polizzi di Sorrentino et al. (2016).

However, they understand the use phase in the classic LCA sense, as one part of the life cycle of a product. Hence, behavioural science support should improve 'behaviour-driven ecodesign' but not consumption patterns.

This is in accordance with the ISO 14040 norm, which sets the focus on products, manufactured or consumed.

> *'The increased awareness of the importance of environmental protection, and the possible impacts associated with products 1), both manufactured and consumed, has increased interest in the development of methods to better understand and address these impacts. One of the techniques being developed for this purpose is life cycle assessment (LCA).'* (ISO, 2006, p. 4)

Acknowledging the act of consuming does not propose an alternative perspective, here. By contrast, it seems that the consumption of products refers to the use phase of products, a step in the life cycle chain which needs to be included anyway.

Subsequently, the idea of improved use phase modelling was picked up by Pohl et al. (2019b), who argued that generally, there should be an increased focus on the use phase in LCA because it very much influences the general outcome of studies (see also Suski et al., 2020). Although the logic of Polizzi di Sorrentino et al. (2016) is internally true and the work can count as an important contribution to the methodological development of LCA, it still puts products into focus and reduces people to mere users of such products. This is fine as long as the goal is to increase the significance of LCA in the increasingly important ecodesign processes (see Daae and Boks, 2015; Lettenmeier, 2018; Liedtke et al., 2014). The importance of the use phase for resource extraction was already provided by Schmidt-Bleek (1993), which led to the MIPS Approach (material input per service unit). Liedtke et al. (2014) expand the approach to be applicable to the micro level in life cycle inventory analyses. However, this approach does not consider the complex array of action that is a consumption pattern; therefore, it does not lead to assessments of sustainable consumption as we understand it here. Regardless, because including theories and methods from social sciences into LCA is still new, the potential of behavioural science has probably not been ascertained and further work in this field could be beneficial.

Hards (2012) discusses three problems with conventional, social-psychological, and economic models that aim to describe pro-environmental behaviour. First, due to a lack of context for actions, the value–action gap is not adequately addressed, although additional contextual factors are designed to accomplish that (Shove, 2010). Second, the development of habits over time and, hence, pathways for change are mostly neglected. A third issue is the lack of experience in behaviour models due to a focus on, for example, political instruments rather than individuals (Worthington, 1996). The last point especially mirrors the aforementioned critique. The starting point or perspective of an LCA according to Polizzi di Sorrentino et al. (2016) does not adequately account for the consumers.

Pohl et al. (2019b) propose a combination of methods to obtain consumption data with the help of, for example, real-world laboratories (Wanner et al., 2018), sustainable living labs (Liedtke et al., 2015), and household surveys (Greiff et al., 2017; Lettenmeier et al., 2014) to improve LCA models.

Miller and Keoleian (2015) present a framework for LCA to analyse transformative technologies. In this framework, behaviour change can be addressed as an indirect factor which might be relevant because of technological change. However, they provide no clear theoretical groundwork to capture behaviour change and still focus on technological aspects.

Another problem is that behavioural change due to one specific intervention can also trigger behavioural change in other areas (Truelove et al., 2014).

2.2. Rebound effects

Interventions and innovations that aim at a more sustainable production and consumption system often have externalities that decrease the direct environmental potential. These externalities can be observed in many cases where the energy efficiency is increased (e.g. cars, computers, heating, and cooling systems) and the affected products are used more intensively (direct rebound effects) or consumption in other areas is stimulated (indirect rebound effects) as a result. This stimulation originates from, for example, microeconomic savings (e.g. time and money) or psychological effects such as moral licensing and the diffusion of responsibility effect (Santarius and Soland, 2018). In a broader perspective, Sorrel (2010) describes rebound effects simply as unintended increased consumption. The research on rebound effects originates from the field of energy efficiency, but rebound effects are encountered in all three sustainability strategies (see e.g. Buhl and Acosta, [2016b] for rebound effects and sufficiency). Rebound effects are linked to the fundamental question of economic growth, and the phenomenon was first described by Jevons (1865). He observes on a macroeconomic level that the increased efficiency of James Watt's steam engine led to increased demand in coal in the United Kingdom, although the opposite was intended. Rebound effects are well known in the field of LCA but rarely applied. These effects are mostly considered within a study of a distinguished rebound effect (e.g. see Buhl and Acosta, 2016a, 2016b; Font Vivanco et al., 2015; Thiesen et al., 2008). Therefore, the issuing of rebound effects on a broad scale in LCA has not occurred.

Rebound effects emerge as higher order effects (Pohl et al.,

2019a) or enabling effects (Hilty and Aubischer, 2015; Pouri and Hilty, 2018) when analysing innovative production patterns or the production of innovative products because those rebound effects occur outside the value chain in question. In a literature review, Pohl et al. (2019a) examine the inclusion of higher order effects in LCA studies on information and communication technologies (ICT). They show that very few studies include user-related higher order effects (rebound and induction effects). They use scenario modelling and sensitivity analysis rather than obtain primary user data.

When approaching environmental assessment by using the consumption perspective, those same effects occur within the direct field of investigation: the consumption patterns of individuals. Taking more showers due to participation in an urban gardening project would be considered as a rebound effect in product-focused LCA (and therefore dismissed in most studies) but would probably be included when focusing on the consumption pattern. Thus, the missing broad scale inclusion of rebound effects in LCA might not be achieved by more studies on rebound effects but by shifting the perspective from production to consumption.

2.3. Household studies

In an attempt to assess the environmental impact of European consumption, the Joint Research Centre developed a framework to capture consumption on the macro level (nations) and consumers on the micro level (households) (Sala et al., 2019). The defined Consumer Footprint is, however, product-focused, using representative products and predefined areas of consumption (e.g. food and mobility). This builds on existing household studies (e.g. Greiff et al., 2017; Lettenmeier et al., 2014), where surveys of household goods and activities are combined with product LCAs and aggregated in various consumption categories. The overall results and the results for each consumption category show high variances, even within socioeconomic groups, which indicates that environmental impacts are highly sensitive to consumption patterns. This approach is useful for tracking the current state of environmental impacts related to consumption. What is debatable, however, is how to use this approach for specific projects on consumption when consumption as such is not addressed, but the consumed products are only measured and added up. Nevertheless, Sala et al. (2019) provide an extensive overview of several discussions related to assessments of consumption, many of which cannot be addressed in this article.

The problems that arise from the current attempts to assess and promote sustainable consumption can be summarised by using three of the four phases of LCA, omitting the impact assessment:

1) Goal and Scope: System expansion to include higher order effects of domestic consumption indicates that a questionable perspective and functional unit was originally picked. Studying the use phase often accompanies rebound effects. These effects can occur because of microeconomic effects (time or money, Buhl and Acosta, 2016a; 2016b) or psychological effects such as moral licensing (Santarius and Soland, 2018). Here, it is unclear which effects to include, and whether only direct or indirect rebound effects should be included. Often, only price effects are addressed in a statistical manner because data for expenditure and income elasticity are most readily available (Font Vivanco and van der Voet, 2014). To include all types of higher order effects overstretches every LCA project. Switching the functional unit from, for example, carsharing to a household (that uses carsharing), makes such system expansions obsolete.
2) Life Cycle Inventory: As Pohl et al. (2019b) point out, gathering data for use phases and rebound effects with sufficient quality is challenging for an LCA practitioner because life cycle inventory databases do not provide help. The consumption effects that occur are decentralised because consumer products are used in households and not in a monitored company's supply chain. Here, they distinguish between primary data from specific users and secondary data from research panels (for a comparison of both approaches see Buhl et al., 2018). To gather consumption data, additional competences must be acquired. Bringing consumption to the core of the assessment allows for new theories, collaborations, and LCA practitioners from different disciplines.
3) Interpretation of results: Due to the shortcomings in the goal and scope phase, often no conclusion on sustainable consumption can be drawn. Bienge et al. (2019) merely state that there is technological environmental potential for various sharing activities but that additional research is necessary. Font Vivanco et al. (2015) investigate economic rebound effects of carsharing statistically, but do not account for consumption patterns. Thus, LCA can only show potentials (of reduced environmental impacts and threats due to higher order effects), leading always to the conclusion that more research is necessary for any given case. Whether carsharing leads to sustainable consumption patterns, as called for in SDG 12, has not been determined.

Especially in the field of digitalisation the need for further research on consumption is articulated. Hilty and Aebischer (2015) introduce the LES model (life cycle effects, enabling effects, and structural effects) as a framework for environmental assessments of ICT applications. The enabling level draws attention to an affected consumption by including substitution effects (e.g. an e-book reader substitutes traditional books) and induction effects, which describe other stimulated consumption (e.g. a wi-fi printer increases paper consumption). The descriptions and examples are very much technology-focused and do not present a theoretical foundation in the field of consumption. However, Hilty and Aebischer (2015) assert that their model can be extended and that behavioural change should be addressed by researching social practices and lifestyle transformation.

Pouri and Hilty (2018, 2020) present an analysis of the digital sharing economy, based on the LES model, and claim that they expect the largest sustainability potential of the digital sharing economy to be within the enabling part. Here, they consider consumption in terms of resources being consumed (used) in more efficient manners (i.e. the use of underutilised assets, a central aspect of the sharing economy) or substituted. They use the term 'sharing practices' to describe new market activities, which is different to the concept of social practice theories that is being used in the following chapters in this article (Pouri and Hilty, 2020).

In a literature review of assessments of indirect effects of ICT, Bieser and Hilty (2018) conclude that the consumption side of ICT is underexplored. They suggest the inclusion of social practice theories to assess correlated environmental impacts by capturing consumption patterns changing because of ICT. Jaeger-Erben et al. (2015) identify the same research gap, in the context of social innovation and sustainable consumption, and call for the inclusion of environmental assessments to quantify the effects of discussed innovations and consumption patterns. This had already been conducted by Røpke and Christensen (2012), but they omit the connection to LCA. Instead, they use the energy intensity of everyday life as a proxy for environmental relevance. To explain consumption in the field of ICT, they combine social practice theories with the theory of time geography and focus on the time and space in individuals' everyday lives. Nevertheless, this study is an important contribution to the methodological development in environmental assessment.

Speck and Hasselkuss (2015) use LCA data in the form of

products' material footprints to assess social practices in regard to sufficiency. They show that transitions of social practices towards sufficiency in the consumption categories housing, mobility, leisure, and nutrition have a high potential for resource conservation. Although their study has no proper integration of LCA theory, they already provide a better idea of what type of environmental assessments are possible, based on LCA.

We propose that there is a discrepancy between the current state of LCA and the goal to environmentally assess sustainable consumption patterns. Often, consumption is only addressed implicitly and hence not adequately conceptualised. Interdisciplinary approaches should be chosen to tackle this issue, as there is already a body of conceptual work on sustainable consumption in the field of social sciences (e. g. Kaufmann-Hayoz et al., 2012; Kennedy et al., 2015, Warde, 2005). The development in research from a focus of individual buyer behaviour to consumption as a cultural phenomenon, as illustrated by Østergaard and Jantzen (2000), should not be repeated in the field of LCA, but learnt from. In Chapter 3, we take up the stated research need on social practices and consumption. We discuss the central terms and theories that help us build a framework for a holistic environmental assessment of (sustainable) consumption patterns.

3. Relevant concepts for a new framework for modelling consumption

When assessing consumption, we must first clarify the meaning of consumption and corresponding concepts. We use social practice theories as our theoretical foundation to approach consumption, because it offers several advantages that we want to discuss in this chapter. Social practices help describe consumption from a social science perspective while considering resources in equipment and infrastructure necessary in LCA. However, we do not claim that LCA only benefits from practice theory in assessing consumption. Other social theories might have benefits as well, and we generally wish to have an open discussion on alternative theories and approaches, although we do not provide this discussion within this article.

We further elaborate on how social practices and consumption are connected.

Social practice theories are not a unified theory but a broad theoretical programme with different epistemological roots and premises (e.g. see a comparison of Bourdieu's approach to the habituation of the acting body compared to Giddens' theory of 'practical consciousness' and 'discursive consciousness' in Kennedy et al. (2015)). Definitions of concepts often vary between scientific discourses, depending on discipline, scientific school, and goals. This overview neither claims completeness nor intends to repeat previous scientific discussions. Instead, we attempt to focus on aspects central to understanding sustainable consumption and LCA modelling.

3.1. Social practices

Social practice theories are an attempt to explain actions and social order and are described by Reckwitz as follows:

> 'A "practice" (Praktik) is a routini zed type of behaviour which consists of several elements, interconnected to one other: forms of bodily activities, forms of mental activities, "things" and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge. A practice—a way of cooking, of consuming, of working, of investigating, of taking care of oneself or of others, etc.—forms so to speak a "block" whose existence necessarily depends on the existence and specific interconnectedness of these elements, and which cannot be reduced to any one of these single elements.' (Reckwitz, 2002, p. 249, p. 249)

Sowing in the context of an urban garden, for example, can consist of arm movements, tools, knowledge of seasons and ground conditions, and a do-it-yourself attitude. Especially the meanings of practices are an important aspect when aiming for a transition towards sustainability, as fundamental cultural norms are reflected here. Shove (2003) analysed how changing meanings over time influenced the practices of personal hygiene. The interdependency and coordination of actions allow practitioners to conceive them as one entity (Røpke and Christensen, 2012; Schatzki, 2002; Warde, 2005). This conception helps observers understand practices as long as the observer and subject belong to the same culture (Reckwitz, 2002).

Reckwitz concludes that '[t]he single individual – as a bodily and mental agent – then acts as the "carrier" (Träger) of a practice – and, in fact, of many different practices which need not be coordinated with one another. Thus, she or he is not only a carrier of patterns of bodily behaviour, but also of certain routinised ways of understanding, knowing how and desiring.' (2002, p. 250).

To make all the types of activities manageable in observations, Shove and Pantzar (2005a) cluster them in three main groups: material, meaning, and competence (Fig. 1). To find clear abbreviations, *image* is added as a synonym for *meaning* (according to Røpke and Christensen, 2012). Because material includes all types of equipment and natural resources, social practices can be linked to the life cycle inventories of an LCA. This central inclusion of objects not just as symbols and things to interpret and discuss but as things to actively handle so that they constitute behaviour, sets social practice theories apart from other cultural theories (Reckwitz, 2002). The competence category includes the various skills of understanding and practical expertise. Meaning includes emotions, conviction, and moods (Shove et al., 2012).

Practices emerge, exist, and cease to exist over time. In these phases, the connections between material, competence, and meaning are established, maintained, or decommissioned (Shove et al., 2012). This development is difficult to express in a static LCA model. It is important to keep in mind the existence of these stages when data is collected and change is what is aimed for.

According to Giddens' theory of structuration (1984), the actors (carriers) are enabled and constrained in their actions by social structures, but those structures are only (re)produced through social practices (Liedtke et al., 2013). Here, Reckwitz (2002, p. 250) concludes that a practice, as a moderation of actions and structures, is always social, 'as it is a "type" of behaving and understanding that

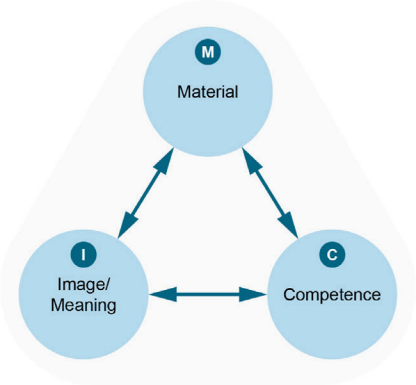

Fig. 1. Social practice comprising Image/Meaning, Competence, and Material (own depiction, based on Shove et al., 2012).

appears at different locales and at different points of time and is carried out by different body/minds. Yet, this does not necessarily presuppose "interactions"'.

Welch and Warde (2015) point out that social practices are the analytical focus of sustainable consumption and not individuals, norms, discourses, or social structures. Thus, social practices overcome the micro–macro dualism of structural and individualist approaches because they do not overemphasise social structures that determine behaviour and practices tend to include the guidance individuals receive from social structures (Giddens, 1984; Liedtke et al., 2013). In this manner, social practice theories are in opposition to what Shove (2010) summarises as the politically dominant ABC (A - attitude, B – behaviour, C – choice) approaches for social change that focus on individual behaviour change (e.g. by 'nudging'), disregarding Bourdieu's (1979, 1977) assertion 'that individual choices more often reflect one's position in society rather than rational calculation' (Kennedy et al., 2015, p. 3).

In an overview of theories on consumer behaviour, Kaufmann-Hayoz et al. (2012) list several action theories and describe the phenomena each theory focuses on. They conclude that most theories manage to reflect consumer action and conscious decision, 'but are not so suitable for less reflected consumer actions, such as everyday routines' (Kaufmann-Hayoz et al., 2012, p. 105). Social practice theories are an exception to this limitation because they offer a holistic perspective of human action (Jaeger-Erben et al., 2015; Kaufmann-Hayoz et al., 2012). Because LCA is also of a holistic nature, we argue that social practice theories provide a plausible addition to LCA in assessments of consumption behaviour.

Despite the social structures that limit practices, individuals also establish individual frameworks associated with specific needs for practices, such as adopting a dog, which is associated with routine walks and feeding (Røpke and Christensen, 2012). Individual frameworks may then be again influenced by social structures. Such choices, which lead to path-dependent biographies (Røpke and Christensen, 2012), are of substantial importance because such dependencies are even more difficult to overcome from a transition perspective.

Because change of the socio-technical system and therefore social practices lead to sustainable consumption and production, modes of change of these reproducing systems are analysed and structured in the literature (e.g. Geels et al., 2015; Liedtke et al., 2017; Warde, 2005). The theories and accompanying discrepancies occurring in this field are disregarded in this article because the goal of LCA is not understanding change but the assessment of a status (status quo or scenario) to deliver a basis for change.

3.2. Consumption

Røpke (2009, p. 2495) defines consumption, from the social practice perspective, as the 'transformation of material goods into waste, while obtaining services from the goods as [an] aspect of various practices'. Thus, consumption is not a practice but is required in most practices (Warde, 2005). Consumption is thus distinct from shopping. In social practice theories, shopping is merely one practice aiming at the procurement of goods for other practices (Røpke, 2009). Because practices are entangled in a web of practices, so is consumption. Hence, consumption patterns, rather than singular consumption activities, must be addressed. This approach adheres to the aforementioned SDG 12. Consumption does not refer to goods that can be accumulated but to the multiplicity of practices these goods are associated with (Buhl, 2016). This definition approximates that of everyday life by Røpke and Christensen (2012). The difference is the focus on the used material. In this regard, consumption is a part of everyday life. In respect to environmental impacts, Røpke and Christensen (2012, p. 350) further stat 'the point is that the *use of resources* always takes place in relation to social practices'.

Because the social lies in the practices and individuals are the carriers of practices, we might call them practitioners, not consumers (Røpke, 2009). The individual is defined by the configuration of practices they participate in. However, expecting the practices to be freely configurable by individuals would be in opposition to the embedding of practices in a web of practices and therefore in the social and material context (Jaeger-Erben et al., 2015). 'In modern societies, most people's life cycle involves schooling and education, jobs in the formal economy, establishing a family, living in buildings, buying goods in shops, using means of transportation and so on' (Røpke and Christensen, 2012, p. 250). Additionally, every practitioner has a history of practices, which influence their meanings, competences, and material base, which steer future participation in practices to a great extent (Røpke, 2009).

When strictly looking through the lens of an LCA practitioner, who strictly wants to assess what is, the modes of the constitution of consumption patterns might seem less relevant. In the environmental calculations (life cycle inventory and life cycle impact assessment), how freely individuals chose their web of practices to participate in is irrelevant; however, this is not true for the first and final part of every LCA, the goal and scope definition and the interpretation of the results including the drawing of conclusions.

The interconnectedness of practices is important when assessing interventions for sustainable consumption. Nicolini (2010) develops an approach for analysing social practices by zooming in on and zooming out of practices. In the first step, Nicolini proposes various methods and theories to better describe and understand the social practices under investigation by focusing on specific aspects of the practice, for example, the sayings and doings, the role of material elements, and infrastructure. In the second step, the zooming out, utilisation of several social theories allows a description and analysis of interconnected social practices in the seamless web of social practices. The latter step is of special importance when assessing consumption patterns. The practices involved in urban gardening (e.g., sowing, watering, harvesting) might also affect practices in mobility, hygiene, and other leisure activities. Therefore, an examination beyond the urban garden is necessary. In the approach of zooming in on and zooming out of practices, Nicolini (2010) understands social practices not as a theory but as a toolbox of theories.

The specific approach to analyse social practices and consumption depends on the empirical case and is not discussed further in this article because we do not conduct an empirical study.

When addressing new consumption patterns, we must reflect on whether we operate on the material/practice level, the project level, or on the individual framework level, because the complexity in the data collection and calculations and the environmental potential might differ. A project describes a cluster of various social practices that emerges from societal and individual frameworks and aim at a single goal, for example, renovating a house (Pred, 1981).

Staffan Linder (1970) describes that in contrast to the understanding of most economists, consumption does not occur only at a point in time but takes time. Hence, new emerging practices always compete with other practices in the recruitment of practitioners (Røpke, 2009). Thus, in environmental assessments of new practices, the killings of old practices must be considered (Shove and Pantzar, 2005b). Thus, although economic growth might be theoretically infinite (disregarding planetary boundaries), consumption cannot grow indefinitely, because of the experienced time constraints. For modelling in LCA, this is important because

interventions and innovations might address the time-use patterns of the practitioner.

Fig. 2 displays the arrangement of social practices in projects, within individual frameworks and social and material context. Social practices might be connected to several other practices and in several projects and individual frameworks (e.g. driving).

Adopting the social practice perspective into LCA, we must conclude that in an attempt to environmentally assess consumption, the functional unit must be a practitioner. This practitioner can be a household (as in Greiff et al., 2017; Lettenmeier et al., 2014; Teubler et al., 2018) or a lifestyle group of citizen-consumers (Spaargaren, 2003; Spaargaren and Oosterveer, 2010). The 'unit processes' in the model that must be identified and described are social practices.

Because social practices link resource use (*materials*) and consumption, social practice theories are a promising foundation for LCA research on sustainable consumption. This link also shows that sustainable consumption is not achieved individually because routinised practices are often non-reflexive (Warde, 2005). Individuals might be able to act reflexively and contrarily to social norms and structures in some instances, but non-reflexive routines are and will be the dominant part of our everyday lives to negotiate the complexity of our modern world (Liedtke et al., 2013; Wilk, 2009: 146).

Examples for goods that are part of a practice are often of obvious nature. If you want to play football, you need a football (Reckwitz, 2002). However, because practices are entangled, so is the material arrangement. As described by Shove (2017), the materials are 'always integrated within and always inseparable from more extensive assemblages'. Shove provides an example of the three practices of building, heating, and watching television (TV). To watch TV, heating is necessary for a comfortable atmosphere, and to heat, a house is necessary. In every practice, there is a need for a power supply. Depending on the practice under investigation, materials can have different roles. Although the boiler has an infrastructural role when watching TV, it is the resource directly engaged in the practice of heating. Contrary to the supply chain logic of LCA, this can be observed ambiguously: Shove explains that what one does, e. g. doing laundry, not only has an effect upstream (demand of the washing machine, electricity and water), but that the design of the washing machine also affects the practices and consumed materials downstream (Shove, 2017). This perspective is at odds with readings of supply and demand models such as the input–output model, from which responsibilities for environmental impacts are deduced.

Although these observations do not exclusively lead to a combination of LCA and social practices, they show that for promoting sustainable consumption, a practice perspective is necessary that emphasises the broad array of material arrangements. We propose that LCA, with its supply chain logic, can do this, although qualitative information is lost in the process of coupling the data of social practices with LCA models. The discussed roles of materials, however, can be converted to LCA logics. The materials practitioners are directly engaged with are the foreground system of the model, and infrastructural materials are the background system.

4. Proposal for a social practice framework to environmentally assess sustainable consumption

The operationalisation of the social practice approach for LCA is about providing a framework for the modelling part (defining system boundaries and environmentally relevant practices). Because social practices exist in a seamless web, a pragmatic approach must be introduced. Because the goal is the reduction of environmental impacts, we propose that environmental potentials in household consumption provide guidance when focusing on relevant practices (Speck and Hasselkuss, 2015). A variety of studies on household impacts can be used here (Buhl et al., 2019a; Greiff et al., 2017; Kalbar et al., 2016; Lettenmeier et al., 2014). Although all those household studies disregard social practice theories, they provide lists of goods and activities, which enable others to indicate associated practices that might be relevant. The starting point, however, will be the zooming in on the practice(s) under investigation (as described by Nicolini, 2010).

In the case of urban gardening, a combination of interviews, observations, and surveys with practitioners and organisers suits the modelling. When relevant practices are identified, they can be described, distinguishing between immaterial aspects (competence and image/meaning) and material aspects (equipment and infrastructure). Although immaterial aspects are relevant to understanding an individual's system and how to develop, for example, interventions, the material part offers the basis for the life cycle inventory phase of an LCA. The combination of what (material) is consumed how (competence) and why (image/meaning) comprises the fundamental strength of this holistic approach. As in production-focused LCA, this social practice based framework can be used for comparisons of different consumption patterns or the identification of environmental hotspots in consumption patterns.

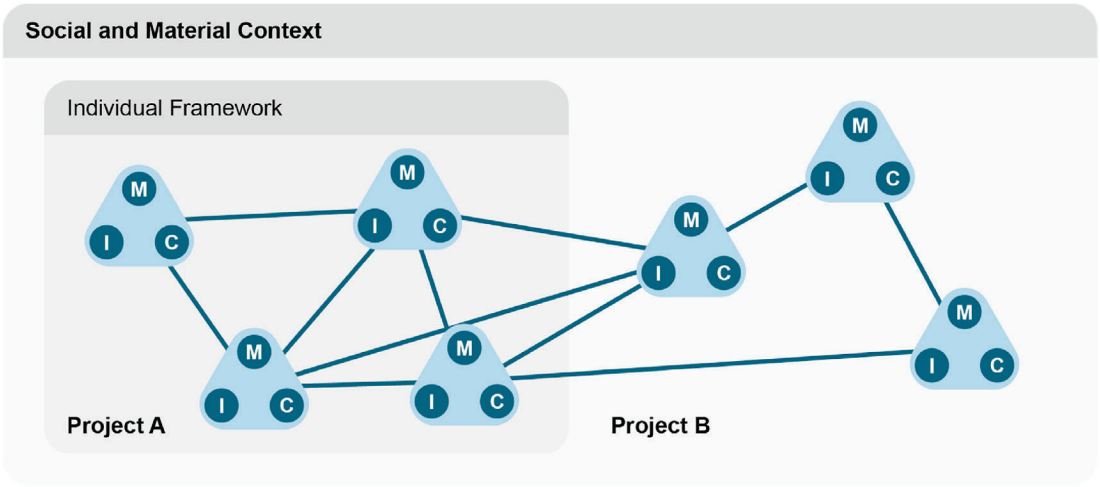

Fig. 2. Practices, projects, and frameworks; M: Material; I: Image/Meaning; C: Competence (own depiction based on Røpke and Christensen, 2012).

After identifying relevant social practices, three steps must be conducted to environmentally assess the consumption patterns (based on Røpke and Christensen, 2012):

- Calculate the environmental intensity of each specific practice
- Describe the connections of practices adopted by practitioners to other practices
- Identify the amount/number of each specific practice carried out by practitioners in a given time frame (e.g. one day, week, or year)

The environmental assessment of each specific practice can be quite straightforward. The description of a practice should include the service unit (e. g. sowing of 20 tomato plants) and the necessary material basis (e.g. seeds, water, soil, tools). From here, a regular product LCA can be conducted, even though as a result we do not have the results for a tomato but for planting them. However, often times we might face unclear or varying qualities and quantities in observed practices. For example, a garden needs several types of construction work over time (building a greenhouse or a raised bed), which can be summarised as manual construction work. Here, we might quantify the regularity from reports of the practitioners (e. g. three sessions a year) but cannot exactly quantify the used materials (e.g. wooden beams and metal connections) as it varies and as the practices do not occur in all the variances during a pragmatic timeframe for observation nor are they expected to be remembered. Here, the LCA practitioner needs to find reasonable assumptions.

In Fig. 3, the social practice based framework to assess sustainable consumption is schematically presented for the example of urban gardening, albeit not extensively. The consumption pattern is characterised in the foreground system by describing social practices and their interconnectedness. The consumed materials are then connected to a material arrangement in the production realm (background system). Instead of exhaustively describing production practices including meaning and competences, the production patterns are addressed in terms of their materiality (material flows). We assume that changing consumption patterns only influences the quantity of practices in the production realm but not their quality. If there is reason to believe that the production practices will fundamentally change, additional modelling is necessary. Although this is not the case for most empirical studies because they are rather limited in temporal and spatial scale, it might be for scenario modelling. LCI databases can be utilised to model and calculate the material flows in the production system, followed by further LCA steps (life cycle impact assessment, interpretation). In addition to practices the agents are engaged in, other practices no longer used might also be of interest, depending on the research question. In the case of time-consuming urban gardening, it is of interest which practices practitioners were engaged with before joining the urban gardening project that are disbandoned now (or engage in to a lesser extent, e.g. riding a motorcycle).

The identification and description of specific social practices is reported to be complicated because there is no clear way to distinguish between variations of the same practice and the emergence of new practices. Christensen and Røpke (2010) describe the case of ICT use in sports and the more specific example of running. They identify multiple ways to include ICT applications in their practices, for example, online maps to organise routes, monitoring speed and pulse, and increasing motivation through online competitions. When does ICT-based running become a new sub-practice, and when does it become a variation of the old running practice? Here, notably, social practices emerge over time and are always subject to change because the social and material context shifts due to political, technological, and social changes. Pragmatic means to distinguish and summarise activities must be found, depending on the research question and the environmental relevance of variations.

To conduct a full LCA according to the social practice based framework, several aspects where differences in production-focused LCA occur must be considered. Thus, what is necessary to address sustainable consumption in environmental assessments?

- Ask the right question

The goal is the overall reduction of the environmental impacts of individuals or households. Innovative products might affect these households, but the competences to use such products, the meaning of the product and activities, as well as the interconnectedness of the practices, must be considered from the beginning.

- Modelling

The modelling does not follow the supply chain of a technological intervention but the interlinked social practices of the consumption pattern. As each social practice is connected to equipment, the supply chains of various products are included in the background system of the model. Because experience regarding the environmental relevance of specific practices is limited, initial studies will have difficulty finding appropriate simplifications and assumptions for the model of consumption patterns.

- Inter- and transdisciplinary approaches

By observing the carriers of social practices, we can identify the social practices. Hence, field research is necessary that can be applied in a transdisciplinary project in a real-world laboratory or sustainable living lab. Conducting interviews and surveys with practitioners requires skills from the field of social sciences.

- Databases

A variety of end-consumer products is addressed in an assessment of consumption patterns; therefore, more consumer goods that represent the most important goods and activities must be defined and assessed. Because life cycle inventory databases such as Ecoinvent tend to avoid the stage of consumer products, datasets for goods must be established (see Sala et al., 2019). Environmentally extended multiregional input–output tables (EE-MRIOT) such as Exiobase in the product by product (PxP) version might be a foundation for such a database because there is already a matrix for the final consumption of households.

- Methods

Although the idea for this article stemmed from thoughts of consequential LCA (what occurs when an individual makes a decision, but by regarding social consequences, not economic consequences), this social practice based framework for LCA is a contribution to LCA research independent from the discourses on, for example, attributional LCA, consequential LCA, and hybrid LCA. (See Guinée et al., [2018] for a discussion on various LCA approaches.). We leave it to others to debate this topic and choose a method for their assessments of consumption.

5. Concluding remarks

Social practices are routinised and often non-reflexive; hence, problems of non-sustainable consumption cannot be solved on the

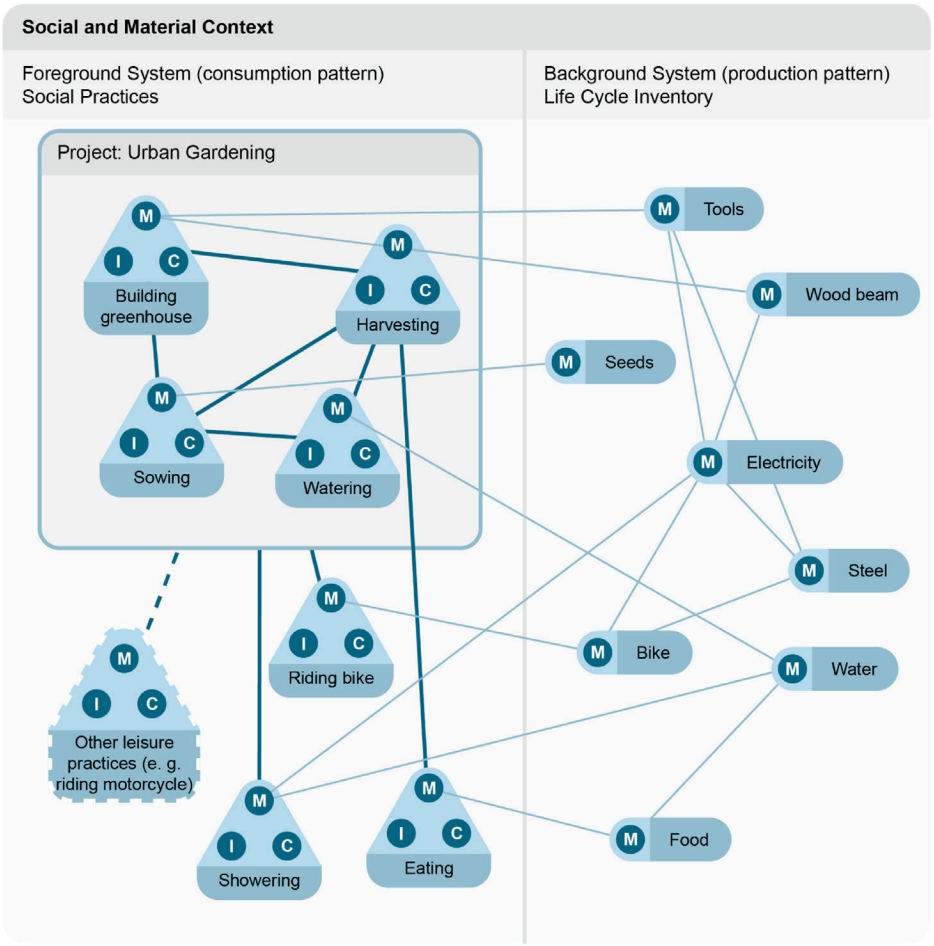

Fig. 3. Social practice based framework for LCA. Consumption pattern is described by interlinked social practices; production pattern is described by material flows in accordance with LCA. Practices not pursued because of the practice(s) under investigation are displayed in dashed lines.

individual level. However, because individuals are reflexive to some extent, and due to innovations, practices evolve over time. As social practices are connected to other social practices, we must zoom out of the practice under investigation to conduct meaningful environmental assessments of consumption patterns. Bringing this infinite complex web of practices to an operational size is a major challenge for LCA practitioners. However, LCA practitioners are already familiar with this task because supply chains are an infinite web of material and energy flows, too.

The difficulty is thus data collection, where observations, interviews, surveys and analyses of documents and symbols demand skills and theories that are new in the world of LCA. Although this difficulty can be considered an obstacle, it is also an opportunity to bring scientists from other disciplines to LCA. This interdisciplinarity should be welcomed because LCA was always a tool of various disciplines.

The proposed social practice based framework for LCA provides neither a new theory nor a fusion of existing theories but a loose combination of two existing toolboxes, that of LCA and that of social practices. In each, there are many partly diverging theories. This unspecificity is neither a weakness nor a sign of a failed attempt but explained by the very broad field of consumption. Thus, the LCA practitioner must find a fitting approach to any given case, research question, or study design. Accordingly, the proposed framework should not be considered a substitute for existing LCA approaches, some of which we have discussed in this article, but as an addition.

Further research is necessary to expand this framework with proposed and tested theories to describe practices and their interconnectedness and consumption in a manner useful for LCA. Problems that always arise in social practice research will also appear in the proposed framework, for example, how to distinguish variances of practices, and how to distinguish practices, subpractices, and projects. Empirical studies are also necessary to present proof of the concepts and adjustments to the framework. The proposed framework is not only a new approach for environmental assessments of consumption but may be a stimulus for conversation.

Despite the difficulties of applying the social practice perspective to LCA, we demonstrated the advantages that make the work worthwhile. Technical advancements that increase efficiency and consistency are insufficient to reach targets that would stop environmental degradation in time. The need for an approach that combines social practice theories and environmental assessments was expressed from both sides: social practice researchers calling for environmental assessments of their work, and LCA practitioners calling for social practices in LCA.

Taking the goal of identifying and assessing consumption patterns seriously means that the functional unit of LCA must cover a broad web of interconnected social practices. We propose a household as the functional unit, whether it is a real singular household or a household category that represents a group of practitioners (lifestyle group). This allows not only an assessment of

whether or not a practice is sustainable when connected to other practices but also of the circumstances under which a practice leads to a consumption pattern that decreases environmental pressures. Another possibility is to identify the necessary prerequisites for practitioners to adopt an environmentally friendly lifestyle.

The assessment of rebound effects becomes obsolete when focusing on interconnected practices. In the process, the proposed social practice based framework offers more than rebound effects to a holistic assessment because no mono-causal relations (e.g. time, money, moral licensing) between one intervention and adjacent activities are identified. Instead, the connections between one practice and another can be complex and described as such if necessary.

We conclude that to address consumption in LCA, a new perspective must be taken from the very beginning, with effects on the goal and scope phase, life cycle inventory, and interpretation. Using existing LCA approaches for product assessments and expanding them seems tempting but does not deliver satisfactory results in the long run.

CRediT authorship contribution statement

Pauline Suski: Conceptualization, Writing - original draft, Writing - review & editing, Visualization, Project administration. **Melanie Speck:** Supervision. **Christa Liedtke:** 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.

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References

Achachlouei, M.A., Moberg, Å., 2015. Life cycle assessment of a magazine, Part II: a comparison of print and tablet editions: LCA of a magazine, Part II: print vs. Tablet. J. Ind. Ecol. 19, 590–606. https://doi.org/10.1111/jiec.12229.

Bienge, K., Clausen, J., Suski, P., Schmitt, M., 2019. Ecological and socio-technical assessment of collaborative consumption: resource efficiency potentials. NachhaltigkeitsManagementForum | Sustainability Management Forum 27, 139–149. https://doi.org/10.1007/s00550-019-00489-7.

Bieser, J., Hilty, L., 2018. Assessing indirect environmental effects of information and communication technology (ICT): a systematic literature review. Sustainability 10, 2662. https://doi.org/10.3390/su10082662.

Bourdieu, P., 1977. In: Outline of a Theory of Practice, first ed. Cambridge University Press. https://doi.org/10.1017/CBO9780511812507.

Bourdieu, P., 1979. Distinction: A Social Critique of the Judgment of Taste. Routledge, New York.

Brandão, M., Weidema, B., 2014. What can LCA learn from economics?. In: Proceedings from the LCA XIV International Conference. San Francisco, pp. 37–42.

Bringezu, S., Bleischwitz, R. (Eds.), 2009. Sustainable Resource Management: Global Trends, Visions and Policies. Greenleaf, Sheffield, UK.

Buhl, J., 2014. Revisiting rebound effects from material resource use. Indications for Germany considering social heterogeneity. Resources 3, 106–122. https://doi.org/10.3390/resources3010106.

Buhl, J., 2016. In: Rebound-Effekte im Steigerungsspiel: Zeit- und Einkommenseffekte in Deutschland, 1. Auflage. Umweltsoziologie. Nomos, Baden-Baden.

Buhl, J., Acosta, J., 2016a. Work less, do less?: working time reductions and rebound effects. Sustainability Science 11, 261–276. https://doi.org/10.1007/s11625-015-0322-8.

Buhl, J., Acosta, J., 2016b. Indirect effects from resource sufficiency behaviour in Germany. In: Rethinking Climate and Energy Policies - New Perspectives on the Rebound Phenomenon.

Buhl, J., Geibler, J. von, Echternacht, L., Linder, M., 2017. Rebound effects in Living Labs: opportunities for monitoring and mitigating re-spending and time use effects in user integrated innovation design. J. Clean. Prod. 151, 592–602. https://doi.org/10.1016/j.jclepro.2017.03.001.

Buhl, J., Liedtke, C., Teubler, J., Bienge, K., Schmidt, N., 2018. Measure or management?—resource use indicators for policymakers based on microdata by households. Sustainability 10, 4467. https://doi.org/10.3390/su10124467.

Buhl, J., Liedtke, C., Teubler, J., Bienge, K., 2019a. The Material Footprint of private households in Germany: linking the natural resource use and socioeconomic characteristics of users from an online footprint calculator in Germany. Sustainable Production and Consumption 20, 74–83. https://doi.org/10.1016/j.spc.2019.05.001.

Buhl, J., Liedtke, C., Teubler, J., Schuster, S., Bienge, K., 2019b. A material footprint model for green information systems – using statistical learning to identify the predictors of natural resource use. Cogent Engineering 6. https://doi.org/10.1080/23311916.2019.1616655.

Christensen, T.H., Røpke, I., 2010. Can practice theory inspire studies of ICTs in everyday life? In: Bräuchler, B., Postill, J. (Eds.), Theorising Media and Practice. Berghahn Books, pp. 233–256.

Daae, J., Boks, C., 2015. Opportunities and challenges for addressing variations in the use phase with LCA and Design for Sustainable Behaviour. International Journal of Sustainable Engineering 8, 148–162. https://doi.org/10.1080/19397038.2015.1010630.

Earles, J.M., Halog, A., 2011. Consequential life cycle assessment: a review. Int. J. Life Cycle Assess. 16, 445–453. https://doi.org/10.1007/s11367-011-0275-9.

Ellen MacArthur Foundation, 2014. Towards the Circular Economy 3 - Accelerating the Scale-Up Accross Global Supply Chains.

European Commission, 2015. Better Regulation Toolbox.

Finnveden, G., Hauschild, M.Z., Ekvall, T., Guinée, J., Heijungs, R., Hellweg, S., Koehler, A., Pennington, D., Suh, S., 2009. Recent developments in life cycle assessment. J. Environ. Manag. 91, 1–21. https://doi.org/10.1016/j.jenvman.2009.06.018.

Font Vivanco, D., van der Voet, E., 2014. The rebound effect through industrial ecology's eyes: a review of LCA-based studies. Int. J. Life Cycle Assess. 19, 1933–1947. https://doi.org/10.1007/s11367-014-0802-6.

Font Vivanco, D., Kemp, R., van der Voet, E., 2015. The relativity of eco-innovation: environmental rebound effects from past transport innovations in Europe. J. Clean. Prod. 101, 71–85. https://doi.org/10.1016/j.jclepro.2015.04.019.

Geels, F.W., McMeekin, A., Mylan, J., Southerton, D., 2015. A critical appraisal of Sustainable Consumption and Production research: the reformist, revolutionary and reconfiguration positions. Global Environ. Change 34, 1–12. https://doi.org/10.1016/j.gloenvcha.2015.04.013.

Giddens, A., 1984. The Constitution of Society: Outline of the Theory of Structuration. University of California Press, Berkeley.

Gossen, M., Pentzien, J., Peuckert, J., 2019. What use is it really for sustainability? Potentials and impacts of peer-to-peer sharing in the domains of accommodation and mobility. NachhaltigkeitsManagementForum | Sustainability Management Forum 27, 125–138. https://doi.org/10.1007/s00550-019-00488-8.

Greiff, K., Teubler, J., Beadeker, C., Rohn, H., 2017. Material and carbon footprint of household activities. In: Living Labs. Design and Assessment of Sustainable Living. Springer, Heidelberg.

Guinée, J.B., Heijungs, R., Huppes, G., Zamagni, A., Masoni, P., Buonamici, R., Ekvall, T., Rydberg, T., 2011. Life cycle assessment: past, present, and future †. Environ. Sci. Technol. 45, 90–96. https://doi.org/10.1021/es101316v.

Guinée, J.B., Cucurachi, S., Henriksson, P.J.G., Heijungs, R., 2018. Digesting the alphabet soup of LCA. Int. J. Life Cycle Assess. 23, 1507–1511. https://doi.org/10.1007/s11367-018-1478-0.

Hards, S., 2012. Tales of transformation: the potential of a narrative approach to pro-environmental practices. Geoforum 43, 760–771. https://doi.org/10.1016/j.geoforum.2012.01.004.

Henriksson, P.J.G., Heijungs, R., Dao, H.M., Phan, L.T., de Snoo, G.R., Guinée, J.B., 2015. Product carbon footprints and their uncertainties in comparative decision contexts. PloS One 10, e0121221. https://doi.org/10.1371/journal.pone.0121221.

Hilty, L.M., Aebischer, B., 2015. ICT for sustainability: an emerging research field. In: Hilty, L.M., Aebischer, B. (Eds.), ICT Innovations for Sustainability. Springer International Publishing, Cham, pp. 3–36. https://doi.org/10.1007/978-3-319-09228-7_1.

Hofstetter, P., Madjar, M., 2003. Linking Change in Happiness, Time-Use, Sustainable Consumption, and Environmental Impacts: an Attempt to Understand Time-Rebound Effects (Final Report to the Society for Non-traditional Technology). BAO and Consultrix, Zürich.

Institute for Global Environmental Strategies, Aalto University, D-mat ltd, 2019. 1.5-Degree Lifestyles: Targets and Options for Reducing Lifestyle Carbon Footprints. Technical Report. Institute for Global Environmental Strategies, Hayama, Japan.

IPCC, 2018. Global Warming of 1.5°C. An IPCC SPecial Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways. In: The Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. World Meteorological Organization, Geneva, Switzerland.

IRP, 2019. Global Resources Outlook 2019: Natural Resources for the Future We Want. International Resource Panel. United Nations Environment Programme, Nairobi, Kenya.

ISO, 2006. DIN EN ISO 14040:2006 Environmental Management: Life Cycle Assessment: Principles and Framework. ISO.

Jaeger-Erben, M., Rückert-John, J., Schäfer, M., 2015. Sustainable consumption through social innovation: a typology of innovations for sustainable consumption practices. J. Clean. Prod. 108, 784–798. https://doi.org/10.1016/j.jclepro.2015.07.042.

Jevons, W.S., 1865. The Coal Question. Macmillan, London.

Jönsson, Å., 1999. Including the use phase in LCA of floor coverings. Int. J. Life Cycle Assess. 4, 321–328. https://doi.org/10.1007/BF02978521.

Kalbar, P.P., Birkved, M., Kabins, S., Nygaard, S.E., 2016. Personal metabolism (PM) coupled with life cycle assessment (LCA) model: Danish case study. Environ. Int. 91, 168–179. https://doi.org/10.1016/j.envint.2016.02.032.

Kaufmann-Hayoz, R., Bamberg, S., Defila, R., Dehmel, C., Di Giulio, A., Jaeger-Erben, M., Matthies, E., Sunderer, G., Zundel, S., 2012. Theoretical perspectives on consumer behaviour - attempt at establishing an order to the theories. In: Defila, R., Di Giulio, A., Kaufmann-Hayoz, R. (Eds.), The Nature of Sustainable Consumption and How to Achieve it. oekom verlag, München.

Kennedy, E.H., Cohen, M.J., Krogman, N.T., 2015. Social practice theories and research on sustainable consumption. In: Putting Sustainability into Practice. Edward Elgar Publishing, pp. 3–22. https://doi.org/10.4337/9781784710606.00009.

Lettenmeier, M., 2018. A Sustainable Level of Material Footprint. Benchmark for Designing One-Planet Lifestyles. School of Art and Design, Aalto.

Lettenmeier, M., Liedtke, C., Rohn, H., 2014. Eight tons of material footprint—suggestion for a resource cap for household consumption in Finland. Resources 3, 488–515. https://doi.org/10.3390/resources3030488.

Liedtke, C., Hasselkuß, M., Welfens, M.J., Nordmann, J., Baedeker, C., 2013. Transformation towards sustainable consumption: changing consumption patterns through meaning in social practices. In: Presented at the 4th International Conference on Sustainability Transitions, Zurich.

Liedtke, C., Bienge, K., Wiesen, K., Teubler, J., Greiff, K., Lettenmeier, M., Rohn, H., 2014. Resource use in the production and consumption system—the MIPS approach. Resources 3, 544–574. https://doi.org/10.3390/resources3030544.

Liedtke, C., Baedeker, C., Hasselkuß, M., Rohn, H., Grinewitschus, V., 2015. User-integrated innovation in Sustainable LivingLabs: an experimental infrastructure for researching and developing sustainable product service systems. J. Clean. Prod. 97, 106–116.

Linder, S.B., 1970. The Harried Leisure Class. Columbia University Press, New York; London.

Miller, S.A., Keoleian, G.A., 2015. Framework for analyzing transformative technologies in life cycle assessment. Environ. Sci. Technol. 49, 3067–3075. https://doi.org/10.1021/es505217a.

Mont, O., 2004. Institutionalisation of sustainable consumption patterns based on shared use. Ecol. Econ. 50, 135–153. https://doi.org/10.1016/j.ecolecon.2004.03.030.

Neef, M., Dettmer, T., Schebek, L., 2019. Comparing carbon performances of mobility services and private vehicles from a life cycle perspective. In: Teuteberg, F., Hempel, M., Schebek, L. (Eds.), Progress in Life Cycle Assessment 2018. Springer International Publishing, Cham, pp. 47–60. https://doi.org/10.1007/978-3-030-12266-9_4.

New Climate Institute, Climate Analytics, 2019. Climate Action Tracker - Warming Projections Global Update.

Nicolini, D., 2010. Zooming in and out: studying practices by switching theoretical lenses and trailing connections. Organ. Stud. 30, 1391–1418. https://doi.org/10.1177/0170840609349875.

Østergaard, P., Jantzen, C., 2000. Shifting perspectives in consumer research: from buyer behaviour to consumption studies. In: Beckmann, S., Elliot, R. (Eds.), Interpretive Consumer Research: Paradigms, Methodologies and Applications. Handelshøjskolens Forlag, København, pp. 9–23.

Piontek, F.M., Rehberger, M., Müller, M., 2019. Development of a functional unit for a product service system: one year of varied use of clothing. In: Schebek, L., Herrmann, C., Cerdas, F. (Eds.), Progress in Life Cycle Assessment. Springer International Publishing, Cham, pp. 99–104. https://doi.org/10.1007/978-3-319-92237-9_11.

Pohl, J., Hilty, L.M., Finkbeiner, M., 2019a. How LCA contributes to the environmental assessment of higher order effects of ICT application: a review of different approaches. J. Clean. Prod. 219, 698–712. https://doi.org/10.1016/j.jclepro.2019.02.018.

Pohl, J., Suski, P., Haucke, F., Piontek, F.M., Jäger, M., 2019b. Beyond production—the relevance of user decision and behaviour in LCA. In: Teuteberg, F., Hempel, M., Schebek, L. (Eds.), Progress in Life Cycle Assessment 2018. Springer International Publishing, Cham, pp. 3–19. https://doi.org/10.1007/978-3-030-12266-9_1.

Polizzi di Sorrentino, E., Woelbert, E., Sala, S., 2016. Consumers and their behavior: state of the art in behavioral science supporting use phase modeling in LCA and ecodesign. Int. J. Life Cycle Assess. 21, 237–251. https://doi.org/10.1007/s11367-015-1016-2.

Pouri, M.J., Hilty, L.M., 2018. Conceptualizing the digital sharing economy in the context of sustainability. Sustainability 10, 4453. https://doi.org/10.3390/su10124453.

Pouri, M.J., Hilty, L.M., 2020. Digitally enabled sharing and the circular economy: towards a framework for sustainability assessment. In: Schaldach, R., Simon, K.-H., Weismüller, J., Wohlgemuth, V. (Eds.), Advances and New Trends in Environmental Informatics. Springer International Publishing, Cham, pp. 105–116. https://doi.org/10.1007/978-3-030-30862-9_8.

Pred, A., 1981. Social reproduction and the time-geography of everyday life. Geogr. Ann. Ser. B Hum. Geogr. 63, 5. https://doi.org/10.2307/490994.

Reckwitz, A., 2002. Toward a theory of social practices: a development in culturalist theorizing. Eur. J. Soc. Theor 5, 243–263. https://doi.org/10.1177/13684310222225432.

Reike, D., Vermeulen, W.J.V., Witjes, S., 2018. The circular economy: new or refurbished as CE 3.0? — exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options. Resour. Conserv. Recycl. 135, 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027.

Røpke, I., 2009. Theories of practice — new inspiration for ecological economic studies on consumption. Ecol. Econ. 68, 2490–2497. https://doi.org/10.1016/j.ecolecon.2009.05.015.

Røpke, I., Christensen, T.H., 2012. Energy impacts of ICT – insights from an everyday life perspective. Telematics Inf. 29, 348–361. https://doi.org/10.1016/j.tele.2012.02.001.

Sala, S., Benini, L., Beylot, A., Castellani, V., Cerutti, A., Crenna, E., Diaconu, E., Sanyé-Mengual, E., Secchi, M., Sinkko, T., Pant, R., 2019. Consumption and Consumer Footprint: Methodology and Results (Technical Report). Joint Research Center (JRC), Ispra.

Santarius, T., Soland, M., 2018. How technological efficiency improvements change consumer preferences: towards a psychological theory of rebound effects. Ecol. Econ. 146, 414–424. https://doi.org/10.1016/j.ecolecon.2017.12.009.

Schatzki, T.R., 2002. The Site of the Social a Philosophical Account of the Constitution of Social Life and Change. Pennsylvania State University Press, University Park.

Schmidt-Bleek, F., 1993. Wieviel Umwelt braucht der Mensch? MIPS - das Maß für ökologisches Wirtschaften. Birkhäuser, Berlin.

Shahmohammadi, S., Steinmann, Z., Clavreul, J., Hendrickx, H., King, H., Huijbregts, M.A.J., 2018. Quantifying drivers of variability in life cycle greenhouse gas emissions of consumer products—a case study on laundry washing in Europe. Int. J. Life Cycle Assess. 23, 1940. https://doi.org/10.1007/s11367-017-1426-4.

Shove, E., 2010. Beyond the ABC: climate change policy and theories of social change. Environ. Plann. 42, 1273–1285. https://doi.org/10.1068/a42282.

Shove, E., 2017. Matters of practice. In: The Nexus of Practices: Connections, Constellations, Practitioners. Routledge, London, pp. 155–168.

Shove, E., Pantzar, M., 2005a. Consumers, producers and practices: understanding the invention and reinvention of nordic walking. J. Consum. Cult. 5, 43–64. https://doi.org/10.1177/1469540505049846.

Shove, E., Pantzar, M., 2005b. Fossilisation. Ethnol. Eur. 35, 59–63.

Shove, E., Pantzar, M., Watson, M., 2012. The Dynamics of Social Practice: Everyday Life and How it Changes. SAGE, Los Angeles.

Sorrell, S., 2010. Mapping rebound effects from sustainable behaviours - key concepts and literature review. SLRG Working paper 01-10. http://www.sustainablelifestyles.ac.uk/sites/default/files/projectdocs/slrg_working_paper_01-10.pdf.

Spaargaren, G., 2003. Sustainable consumption: a theoretical and environmental policy perspective. Soc. Nat. Resour. 16, 687–701. https://doi.org/10.1080/08941920309192.

Spaargaren, G., Oosterveer, P., 2010. Citizen-consumers as agents of change in globalizing modernity: the case of sustainable consumption. Sustainability 2, 1887–1908. https://doi.org/10.3390/su2071887.

Speck, M., 2016. Konsum und Suffizienz: eine empirische Untersuchung privater Haushalte in Deutschland, Research. Springer VS, Wiesbaden.

Speck, M., Hasselkuss, M., 2015. Sufficiency in social practice: searching potentials for sufficient behavior in a consumerist culture. Sustain. Sci. Pract. Pol. 11, 14–32. https://doi.org/10.1080/15487733.2015.11908143.

Suski, P., Pohl, J., Frick, V., 2020. All you can stream: investigating the role of user behavior for greenhouse gas intensity of video streaming. In: Proceedings of the 7th International Conference on ICT for Sustainability. Presented at the ICT4S2020: 7th International Conference on ICT for Sustainability. ACM, Bristol United Kingdom, pp. 128–138. https://doi.org/10.1145/3401335.3401709.

Teubler, J., Buhl, J., Lettenmeier, M., Greiff, K., Liedtke, C., 2018. A household's burden – the embodied resource use of household equipment in Germany. Ecol. Econ. 146, 96–105. https://doi.org/10.1016/j.ecolecon.2017.10.004.

Thiesen, J., Christensen, T.S., Kristensen, T.G., Andersen, R.D., Brunoe, B., Gregersen, T.K., Thrane, M., Weidema, B.P., 2008. Rebound effects of price differences. Int. J. Life Cycle Assess. 13, 104–114. https://doi.org/10.1065/lca2006.12.297.

Truelove, H.B., Carrico, A.R., Weber, E.U., Raimi, K.T., Vandenbergh, M.P., 2014. Positive and negative spillover of pro-environmental behavior: an integrative review and theoretical framework. Global Environ. Change 29, 127–138. https://doi.org/10.1016/j.gloenvcha.2014.09.004.

United Nations, 2019. Special Edition: Progress towards the Sustainable Development Goals.

Wanner, M., Hilger, A., Westerkowski, J., Rose, M., Stelzer, F., Schäpke, N., 2018. Towards a cyclical concept of real-world laboratories: a transdisciplinary research practice for sustainability transitions. disP - The Planning Review 54, 94–114. https://doi.org/10.1080/02513625.2018.1487651.

Warde, A., 2005. Consumption and theories of practice. J. Consum. Cult. 5, 131–153. https://doi.org/10.1177/1469540505053090.

Weidema, B.P., 1993. Market aspects in product life cycle inventory methodology. J. Clean. Prod. 1, 161–166. https://doi.org/10.1016/0959-6526(93)90007-X.

Weidema, B., 2003. Market Information in Life Cycle Assessment.

Welch, D., Warde, A., 2015. Theories of practice and sustainable consumption. In: Reisch, L., Thøgersen, J. (Eds.), Handbook of Research on Sustainable Consumption. Edward Elgar Publishing, Cheltenham, UK, pp. 84–100.

Wilk, R., 2009. The edge of agency: routines, habits and volition. In: Shove, E., Trentmann, F., Wilk, R. (Eds.), Time, Consumption and Everyday Life: Practice, Materiality and Culture. Bloomsbury Academic, Oxford, pp. 143–154.

Worthington, K.L., 1996. Self as Narrative: Subjectivity and Community in Contemporary Fiction, Oxford English Monographs. Clarendon Press, New York.

Zamagni, A., Guinée, J., Heijungs, R., Masoni, P., Raggi, A., 2012. Lights and shadows in consequential LCA. Int. J. Life Cycle Assess. 17, 904–918. https://doi.org/10.1007/s11367-012-0423-x.

3 Publication B: On urban sharing

Suski, P., Palzkill, A., Speck, M., 2023. Sufficiency in social practices: An underestimated potential for the transformation to a circular economy. *Front. Sustain. 3*, 1008165. https://doi.org/10.3389/frsus.2022.1008165

The circular economy is still unsuccessful in regard to its promise to transform our production and consumption system, which cannot be observed. One problem is the focus on strategies of efficiency and effectivity, while research suggests that sufficiency-oriented strategies of refuse, rethink and reduce show highest environmental potential. Analysing the case of urban gardening provides insights in the transformative potential sufficiency-oriented urban sharing initiatives. By zooming in and out of urban gardening, using semi-structured interviews and online-workshops, meanings, competences and materials of urban gardening as well as connected social practices are being investigated. Results show that urban gardening contests the paradigm of availability by inheriting the meaning of 'enough'. Urban gardening is furthermore connected in a nexus of social practices by shared meanings, which affects shopping food, urban mobility and travelling. This proves that small interventions can have big transformative potential. It is further shown that sufficiency, which combines reduction of material demand while increasing quality of life, is not necessarily as radical as often proposed and a promising strategy within the context of the circular economy. Further quantitative environmental assessments are necessary in order to identify the specific environmental potential of urban gardening and further urban sharing activities.

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Sufficiency in social practices: An underestimated potential for the transformation to a circular economy

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To date, the circular economy has fallen short of its promise to reduce our resource demand and transform our production and consumption system. One key problem is the lack of understanding that highly promising strategies such as refuse, rethink, and reduce can be properly addressed using research on sufficiency. This article argues that a shift in focus is required in research and policy development from consumers who buy and handle circularly designed products to consumption patterns that follow the logic of sufficiency and explain how sufficiency-oriented concepts can be incorporated into existing social practices. The authors show that sufficiency is not necessarily as radical and unattractive as is often claimed, making it a suitable yet underrated strategy for sustainability and the transition to an effective circular economy. The case of urban gardening shows that small interventions can have far-reaching effects and transform consumption patterns as the logic of availability is contested by newly developed concepts of "enoughness" and opposition to "über-availability." The authors propose utilizing comprehensive state-of-the-art theories of consumption and human action when developing strategies and policies to make the circular economy sustainable while being more critical of utilitarian approaches. Using social practice theories that have proven to be beneficial allows human actions to be comprehensively analyzed by recognizing their embeddedness in social and material frameworks; addressing the meaning, competences, and materials of routinized human behavior; and examining indirect effects.

KEYWORDS

circular economy, sufficiency, theories of social practice, sustainability transition, sustainable consumption, urban garden

1. Introduction

One of the currently most popular and widely discussed strategies for achieving sustainability is the transformation of our linear make-use-dispose economy to a circular economy (CE) in which the resource base operates in a circular manner within a society (abiotic materials) or in sustainable exchange with the biosphere (biotic materials). This is sorely needed as several planetary boundaries are being crossed at once due to our high resource extraction and emissions, making it essential to rethink and reorganize our production and consumption systems (Steffen et al., 2015). For most industrialized countries, lifestyles are associated with average resource demand of 40 to 50 tons per capita per year (Bringezu and Bleischwitz, 2009). In this context, Lettenmeier (2018) advocates for a sustainable material footprint of eight tons per capita per year by 2050. To successfully transition to a sustainable circular economy that is truly within planetary boundaries, it is therefore absolutely essential that resource consumption be reduced. At the same time, a decent living standard for all should be achieved, meaning that a minimum level of consumption that allows every individual to live a good life must be ensured (Fuchs et al., 2021).

It is often said that the CE is based on the consistency strategy and hence follows a different logic than many other environmental protection approaches that rely exclusively on efficiency (Brinken et al., 2022). Consistency refers to the circularity of materials, using them correctly instead of efficiently so that no waste occurs (Brinken et al., 2022; Speck et al., 2022). Some even think that this idea of effective resource handling will be enough to achieve absolute sustainability (McDonough and Braungart, 2002). This reductionist view is certainly easy to criticize as perfect material cycles are not technologically achievable in the foreseeable future in many cases.[1] More fundamentally, consistency alone is not sufficient, either, as every material potentially entering the cycle must originate from nature, and so absolute consumption levels must be taken into account to limit environmental degradation (Bringezu and Bleischwitz, 2009; Lettenmeier et al., 2014).

More comprehensive approaches to the CE go even further and describe several sub-strategies that are not limited to the consistency strategy and are open to sufficiency. The Ellen MacArthur Foundation (2014) distinguishes between four different kinds of circles, describing the "power of the inner circle" as the potential to reduce harm to the environment and society by keeping materials in use for longer to decrease efforts to repair, remanufacture, and recycle. While this does not necessarily have to be interpreted as a call for sufficiency, it already points to the problem of circular material flows being energy- and labor-intensive, leading to further environmental degradation due to our current energy provision system as well as the degradation of material quality. Morseletto (2020) shows that, in contrast to the problem of high material throughput within a CE, most CE targets do not consider an overall reduction of materials but rather focus on recovery rates, resource efficiency, recycling targets, and waste reduction. In their critical discussion of the failed promises of CE, pointing out dissipative losses, energy demand, and complex global value chains, Corvellec et al. (2022, p. 426) state: "It is therefore important to dispel the myth that circular systems are necessarily more environmentally sustainable than linear systems."

Several strategies that come under the umbrella of CE are now discussed in academia regarding their environmental potential and, e.g., the art of innovation (Potting et al., 2017; Reike et al., 2018). What started as the reduce, reuse, and recycle hierarchy (which still essentially forms the basis of the waste hierarchy in many countries, including the European Union) can now be further distinguished as more comprehensive sets of resource value retention options (Ros; see Reike et al., 2018 for a critical literature review on the conceptualizations of CE and the various RO strategies). What Potting et al. (2017) and Reike et al. (2018) have in common is the idea that the refuse RO offers the greatest environmental potential. However, while Potting et al. (2017) focus exclusively on production and product design, Reike et al. also emphasize the role of consumption and even stress post-materialist lifestyles. While they do not make explicit connections to the sufficiency debate, they invite researchers to work out the connections between CE and sustainability concepts.

On the one hand, great hope is placed in the concept of sufficiency as a true all-rounder that aims at a total reduction of resource consumption by shifting the focus from economic growth to a good life (Schneidewind and Zahrnt, 2014; Wynes and Nicholas, 2017; Hüttel et al., 2018). On the other hand, sufficiency is often excluded from current debates on CE (Bocken et al., 2022). This has created a paradoxical situation in that the necessity of a radical transformation of our production and consumption system has finally been acknowledged by all stakeholders working on CE (Welch et al., 2017; European Commission, 2020), but when it comes to implementing policies, comprehensive sufficiency strategies are off the table as they are too radical (paradoxical because it is difficult to achieve radical results without radical measures). It is far more often the case that sufficiency and its counterpart overconsumption are presented as consumer issues in that consumption science of the last 20 years is entirely neglected (Warde, 2005; Røpke, 2009; Shove, 2010; Camacho-Otero et al., 2018; Bocken et al., 2022). As a result, the environmental potential of sufficiency is often disregarded as its "radicality," which means it cannot have a truly large-scale impact on society. It is therefore only implemented within small niches that have no or only minor systemic impact (Speck, 2016; Gossen and Kropfeld, 2022).

1 See Reuter et al. (2019) for an in-depth discussion on metallurgical, thermodynamical and infrastructural issues.

This becomes a self-fulfilling prophecy that has been increasingly criticized in recent years as research demonstrates that CE concepts struggle to deliver on their promises (Welch et al., 2017; Morseletto, 2020; Zwiers et al., 2020; Jaeger-Erben et al., 2021; Corvellec et al., 2022).

Thus, a clear sense of ambivalence toward the debates on sufficiency can be identified at this point. Sufficiency is seen as a form of renunciation, but if we take the strategy of sufficiency seriously, it, in fact, operates according to a very different logic. It stands in contrast to the dominant market logic that shapes production and consumption globally. This different logic of renunciation is often only found in niches. Nevertheless, some sufficiency-related social practices are also quite widespread (e.g., cycling) or even considered socially desirable (e.g., reducing food waste).

Research on sustainable transitions emphasizes the importance of protected spaces for sustainable niche innovations (Kemp et al., 1998; Raven, 2005; Schot and Geels, 2008). Niches are characterized by alternative and proactive actions and the development of alternative ideas and innovations in the respective fields, for example, community-supported agriculture which also supports non-processed and plant-based food. Thus, niches provide an opportunity to do something different. Niches are shielded from current logics and can define themselves as different (Fuenfschilling and Truffer, 2014). Niches, therefore, emerge precisely where actors try out alternatives that differ from the dominant logic and the rules and routines of the regime and where safe spaces are created for alternative actions (Geels and Schot, 2007). This not only involves technological innovations but also "novel ways of doing (practices), thinking (narratives, imagination) and organizing (structure)" (Ehnert et al., 2018, p. 2) that break with dominant, often unsustainable logic (which is why they are novel or different in the first place), and need to be scaled up to achieve a systemic change (Ehnert et al., 2018; Von Wirth et al., 2019; Loorbach et al., 2020).

Sufficiency can in fact be located precisely in such niches of alternative logics and in the doing, thinking, and organizing of a new or alterative way of doing something that could potentially be scaled up. For example, plant-based diets using community-grown vegetables represent just such an alternative way of doing things and are currently still a (growing) niche. These may well differ from the incumbent agri-food systems based on an animal- and machine-intensive, conventional, industrial system, and its associated rules and logic (El Bilali, 2019). The level of sufficiency depends heavily on how well it fits into existing logic and, of course, on what exactly is understood by sufficiency. As Sandberg (2021) shows, sufficiency is possible at different stages: the current animal- and plant-based diet with its (overly) high intake of meat and meat products could be substituted by an entirely vegan diet. However, this still seems very radical. Alternatively, it could be changed to a plant-based diet with a very low intake of meat and meat products, which would be less radical and potentially more realistic, not least because it is linked to the logic of the current food system.

When looked at from a transition perspective, the ambivalence of sufficiency becomes apparent. It can usually be assumed that niches need to find points of contact with the dominant logic of the current system to scale up and transform the system itself (Augenstein et al., 2020). This can work very well in conjunction with a CE that is often based on dominant logic (optimization of resource use). Thus, depending on the degree of connection to the CE, it would appear that sufficiency can do both: find points of connection to the existing system and be extremely radical. From the perspective of transitioning to a CE, sufficiency is thus ambivalent in the best sense.

This article aims to explore how sufficiency can spread in our consumption system by providing a low-threshold entry point. The authors have approached this task from the perspective of social practice theories. A theoretical discussion on how sufficiency can be identified using social practice theories is followed by an empirical study that illustrates how sufficiency spreads within consumption systems. This is demonstrated by analyzing a specific form of urban gardening, namely an aquaponic system called "Farmbox."

2. Theoretical background: What makes social practices sufficiency-oriented?

Over the last few decades, we have missed out on a great deal of potential to reduce environmental impacts by reducing our energy demand as much of the academia and most political institutions have relied on either the homo economicus or the effectiveness of behavioral economics, such as nudging (Shove, 2010; Hampton and Adams, 2018). The same mistakes should be avoided when discussing CE again (Zwiers et al., 2020). Research on (sustainable) consumption instead suggests shifting the focus from consumers and their behavior to routinized types of behavior itself using social practice theories (Shove, 2010; Huber, 2017; Welch et al., 2017; Hampton and Adams, 2018; Suski et al., 2021).

In a literature review on consumption in the context of CE, Camacho-Otero et al. (2018) show that most scientific papers use utilitarian approaches, such as the theory of planned behavior, and economic approaches, such as rational choice (both focusing on "the consumer"), while studies that rely on social practice theories (focusing on consumption) are in minority. Studying this situation, Welch et al. (2017, p. 6) concluded that "[t]he imagined futures of Circular Economy often elide everyday life, even while acknowledging the centrality of consumption to the model" and that even concepts that put special emphasis on aspects such as collaborative consumption are "offering little by way of projected context as to how such changes will come about, and a simplistic understanding of

consumption." The fundamental problem is clear: how are we to achieve the much-needed, fundamental transformation of our consumption system when we do not really understand consumption or transformation? Is this going to happen by chance or wishful thinking? Rabiu and Jaeger-Erben (2022) just recently provided a model to address the appropriation and routinization of circular consumer practices with the help of social practice.

To gain a better understanding of what sufficiency-oriented social practices are and how they can be identified, social practice theories are introduced along with a brief overview of the research on sufficiency itself.

2.1. Social practice theories

Social practice is a routinized type of behavior that incorporates a bundle of things, such as knowledge, skills, ideas, meanings, etc. (Reckwitz, 2002). The closely linked elements of a social practice make specific behavior somewhat complex as multiple aspects have to come together (e.g., driving includes the car, the road, knowing how to shift gears, and the masculine urge to burn oil; Shove et al., 2012). However, as all these aspects of a given social practice, such as driving, seem to fit together so naturally, we perceive them as one entity, one social practice, which helps to reduce complexity, enabling orientation and easing communication. If I tell my colleague that I am going to drive home now, they have a very clear understanding of what I am about to do even though my actions are as complex as driving, and they might not know anything about the specific route, the car, or my personal driving skills.

The meanings, materials, and competences of social practices (Shove et al., 2012) are shared within or located in social and material contexts. Therefore, social practices do not describe individual behaviors but rather behaviors that exist as entities in themselves within society. A practice "provides a template in terms of which actions are adjusted and calibrated [...] [but] not all enactments of practice are consistent or faithful and that each performance is situated and, in some respect, unique" (Shove et al., 2012, p. 122). Individuals participate in social practices (and hence are the carriers of social practices), and social practices can only be observed as they are performed by them. Lifestyles can therefore be described by the combination of social practices involved in everyday life (Suski et al., 2021; Kropfeld, 2022). However, we are not totally free in choosing social practices as they are themselves linked in an infinite network of social practices within our social-material contexts (Røpke and Christensen, 2012). Eating is connected to cooking (or driving to a restaurant) and cooking is connected to grocery shopping, which is connected to going to work, which is connected to paying attention in school, etc. While these connections are not necessarily definitive necessities on an individual level (one can drop out of school, steal food, and still be able to eat), it is difficult to break free from many path dependencies. When discussing strategies to reduce environmental impacts, keeping this network characteristic in mind is crucial to address the unintended side effects of a given intervention (Suski et al., 2021).

Shove et al. (2012) observed that social practices emerge, exist, and cease to exist over time by building and losing connections between the dimensions that constitute the practice. Emerging social practices, also called proto-practices, are often found in niches where the connections between the various elements are only in the making and more prone to change within shorter periods of time.

As some sort of material base is crucial in all social practices, which we also consider to be actual physical entities rather than just symbols (Warde, 2005; Shove, 2017), we are able to address consumption by analyzing the materials that are being transformed into waste by utilizing them as part of the participation in social practices (Røpke, 2009; Suski et al., 2021). Products and infrastructure are used within social practices, and once they are used up, they become waste (in the form of emissions, municipal solid waste, etc.).

2.2. Sufficiency

Sufficiency is, in some regards, similar to CE. There has been an increasing amount of research in recent years as well as high hopes for sustainable transformations, but no coherent definition as scholars from very different disciplines are working on it with different agendas (Jungell-Michelsson and Heikkurinen, 2022). In principle, sufficiency or somewhat similar concepts (e.g., voluntary simplicity, simplification; Alexander and Ussher, 2012) aim to achieve a good life by reducing the material wants in our lives (Spangenberg and Lorek, 2019). This means that the consumption levels of many will decrease as the focus shifts to alternative measures and cultures of wellbeing and wealth (Schneidewind and Zahrnt, 2014). The goal is to reduce the pressure society puts on the environment by reducing resource demand (Speck and Hasselkuss, 2015). Typical examples include a vegan diet, avoiding flights and other elaborate long-distance travel, reducing individual car use, or moving to a smaller suburban house or flat. A sample calculation by Speck (2016) demonstrates that sufficiency lifestyles reduce resource demand by 30–70%.

As sufficiency provides a fundamentally different approach to living compared to the growth and efficiency-oriented society of the past 250 years, the research field is multi- and inter-disciplinary, ranging from economics and marketing (Gossen et al., 2019; Kropfeld and Reichel, 2021; Bocken

et al., 2022) to political sciences (Spangenberg and Lorek, 2019) and environmental modeling (Speck and Hasselkuss, 2015), to name but a few. See also Santarius et al. (2022) for a truly multi-disciplinary approach to addressing digital sufficiency.

Depending on one's scholarly background and goals, sufficiency is defined in various ways: from a radical concept of non-consumption (Princen, 2005; Stengel, 2011) and systemic change to a low-threshold option that fits into our daily lives, such as cycling daily commutes (Speck, 2016). Furthermore, several degrees of sufficiency are defined by Fischer et al. (2013). They argue that a low level of sufficiency can be found in many lifestyles, e.g., lowering the interior temperature by 1°C (from 20 to 19°C) or not using a car.

Sufficiency in the field of nutrition is associated with diets, whereby a plant-based diet with no food waste is often the starting point toward greater intellectual engagement with the production and consumption of food and the general field of sufficiency (Speck, 2016).

Recently, Bocken et al. (2022) defined sufficiency as having enough to live well without excess, satisfying essential needs to live and function comfortably, while prioritizing quality of life in work, education, and leisure, but not needlessly striving to satisfy infinite human material wants. "Enoughness" was coined as a central description of what is enough for the individual while also leaving enough for everyone else (Fuchs et al., 2021). Similarly, Speck (2016) defines sufficiency in private households as implementing modified cultural techniques in the form of social practices in as many household-related consumption areas as possible. What is important here is that everything is done under the premise of reducing negative ecological and social impacts, thus underlining the idea that even though the ecological impact is not always a leading aspect, ecological reduction often occurs. This idea is also taken up by Sandberg (2021), who identifies several types of pathways to sufficiency: absolute reductions, i.e., reducing the amount of consumption; modal shifts, i.e., shifting to a consumption mode that is less resource-intensive; product longevity, i.e., extending product lifespans; and sharing practices, i.e., sharing products among individuals, and notes that several sufficiency practices have an environmental benefit.

Sufficiency is connected to the circular economy by its shared goal of reducing dependencies on raw material extraction and the associated environmental impacts. However, in contrast to strategies of consistency (e.g., reuse and recycle), there are no actual material cycles as the goal of sufficiency is the absence of material throughput.

Whereas an extensive body of literature addresses a definition of sufficiency, only a few go into the discourse on social practices (Lahusen et al., 2016; Speck, 2016; Kropfeld, 2022). A clear description (or even a broad discussion) of how sufficiency can be identified from the social practice perspective is lacking.

2.3. Sufficiency in social practices

Adopting the perspective of social practices, sufficiency is a set of daily practices that avoid the demand for energy, materials, land, water, and other natural resources while delivering wellbeing for all within planetary boundaries. Sufficiency bridges the inequality gap by setting clear consumption limits to ensure fair access to space and resources (Saheb, 2021).

In the investigation of routines and practices, a variety of examples of more or less sufficient practices in everyday life are available (Sandberg, 2021). Many social practices and (social) initiatives such as neighborhood gardening, bicycle lanes, and corporate calls for less consumption are associated with sufficiency (Gossen et al., 2019; Suski et al., 2021). However, focusing exclusively on decreasing the use of material through social practices is not enough to identify sufficiency. Efficiency also aims at quantitatively reducing the materials used. In sufficiency, one could argue that the quality of the material base is different (a car is not replaced by a lighter car but rather by a bicycle). This, however, would require a specific situational analysis as aspects such as poverty should not be confused with sufficiency. A bicycle can also be ridden for sport and to compensate for sedentary work to increase productivity, not just to get from A to B. One would not necessarily refer to exercise as sufficiency. Hence, the meanings of practices are important to identify sufficiency.

What meanings associated with sufficiency require a prior definition of sufficiency? Environmental concerns? Yes. Stress reduction? Maybe. Positive self-image? No. This article argues that there is a broad gray area of meaning that may indicate sufficiency, but not necessarily. To the authors' knowledge, there is no coherent list of meanings of practices associated with sufficiency. Furthermore, their qualitative nature prohibits a definitive list. In her literature review on sufficient social practices, Kropfeld (2022) compiled a list of meanings (as well as competences, materials, and rules) that are found in the literature on social practices referred to as sufficiency-related. However, this does not mean that every meaning (or material/competence) is in itself related to sufficiency. For instance, one could examine the social practice of renting goods and the identified meaning of "access to a greater variety of goods" (Kropfeld, 2022, p. 13; based on Retamal, 2019). This is the complete opposite of sufficiency as it promotes the ideas of materialism and growth. Depending on what one aims for in a study, it can be argued that a social practice with no characteristics of sufficiency in its meaning cannot be considered a sufficiency-oriented social practice (as is the case with renting goods in Kropfeld, 2022).

In addition to sufficiency-oriented meanings, access to specific sets of competences is necessary to reduce the material demand for social practices or one's lifestyle by participating in new social practices. Growing your own vegetables requires knowledge of sowing, watering, pest control, etc., while repairing

things requires manual skills. Not driving a car to get from A to B requires skills such as riding and maintaining a bike or understanding the rules of public transport. However, in many cases, these competences can be acquired over time by attempting them (learning by participating) as sufficiency is often rather low-tech and low-cost. The first time one repairs a flat tire will take the most effort, but by the fourth time, it will become routine.

Just as competences are relevant to performing specific social practices, so too is access to materials such as tools for repairing things or land for growing plants. Hence, materials can have two characteristics, namely becoming obsolete and being necessary. Again, the question arises as to when can a social practice really be considered sufficiency-oriented. Is this when the materials required have a lower environmental impact than the materials saved? This is a very quantitative understanding, but it is in line with the definition of reducing the use of resources and environmental impacts. This net saving result is often not as easy to estimate as one might assume. For example, Lahusen et al. (2016) analyzed the drying of washed clothes and argued that using a drying rack is a sufficiency-related social practice whereas using a tumble dryer is not as it consumes additional energy. This analysis fails to consider the additional energy consumption for the heating necessary to dry clothes on racks (if clothes are dried indoors during the colder months). Rüdenauer et al. (2008) conducted a life cycle assessment in this case and showed that using a tumble dryer might be an environmentally friendly alternative in cold months depending on specific drying, airing, and heating practices. This example can be taken further by saying that what might have been correctly referred to as sufficiency in the past (drying cloths on racks) is not sufficiency anymore due to the increased energy efficiency of tumble dryers and reduced carbon intensity of our electricity grid (while room heating is mostly still fuelled by oil or natural gas).

Figure 1 provides an overview of sufficiency aspects within several dimensions of social practices. This demonstrates that identifying and scaling up sufficiency-oriented social practices is a complex endeavor with several potential pitfalls as explained above (renting goods, using drying racks). However, it also provides a framework for comprehensive analysis. Furthermore, by giving serious consideration to the connections, it also allows researchers to ask new questions, e.g., how does meaning x correspond to the materiality of social practice y?

Many examples evolve around the idea of abandoning existing social practices, such as driving, while recruiting carriers for other or newly evolving social practices, such as riding a bicycle. However, social practices themselves are also under pressure and able to change over time, as Shove et al. (2012) discuss regarding the history of driving, and Shove (2003) notes regarding cleanliness practices. For sufficiency, this means that connections between the meanings, materials, and competences might loosen in part, but the overall social practice remains. Ways of eating dinner may change in that animal-based food (material) is replaced by plant-based food, but the practice of "having dinner" itself does not change. This remains true even when additional meanings become part of the social practice (environmentalism and animal ethics) and competences change (there is no longer any need to know how to cook a rare steak as there is no blood involved). However, in the infinite network of social practices, one can find abandoned social practices over time when sufficiency prevails, at least in the production realm. When the material of meat becomes detached from the social practice of cooking, there will no longer be a connection to the social practice of slaughtering animals, which will (rightfully) lead to the practice becoming extinct.

The transition from a conventional to a sufficiency-oriented social practice is therefore fluid and often cannot be determined by just one factor.

Another important feature in the context of sufficiency also warrants consideration: non-action. Instead of using a bicycle to get from A to B, one can just stay at A. Or one could go to C instead, which is much closer (a nearby forest instead of a pacific island). In the context of sufficiency, we often underline renunciation as sufficiency is always associated with non-consumption. Empirically, this is a problem as not engaging in a social practice cannot be observed. The practice-as-a-performance perspective is missing. To analyze non-participation (narrative), interviews can be utilized to specifically address social practices that are known to be environmentally intensive but are not identified in surveys or observations, e.g., flying or eating animal products. Here, the authors can find out whether the research participants choose not to fly because of environmental concerns or because they are just scared of flying. To make this manageable (interviewees cannot be asked about every social practice they have not mentioned in a survey), quantitative knowledge of the material world of consumption is necessary to focus on environmentally relevant social practices (Lettenmeier et al., 2014; IGES, 2019).

When placing the research focus on non-action, one must keep in mind that it is not possible to follow the dynamics in social practices to the point where a specific social practice ceases to exist. Research that analyses the dynamics of social practices does so by looking at the past (Shove, 2003; Shove et al., 2012). Instead, one is more likely to examine smaller groups of people not participating in specific social practices, e.g., flying, which does not mean that the social practice itself is already non-existent. Rather, one is searching for the first signs of the disintegration of social practices.

When investigating transition pathways for sufficiency-oriented social practices or assessing the sustainability potential of such practices, it is recommended that a given case be analyzed not as a singular social practice but as part of a network of practices to address side effects (Røpke and Christensen, 2012; Speck and Hasselkuss, 2015; Suski et al., 2021).

In the interim, taking the social practice perspective, it can be concluded that deciding whether or not a social practice

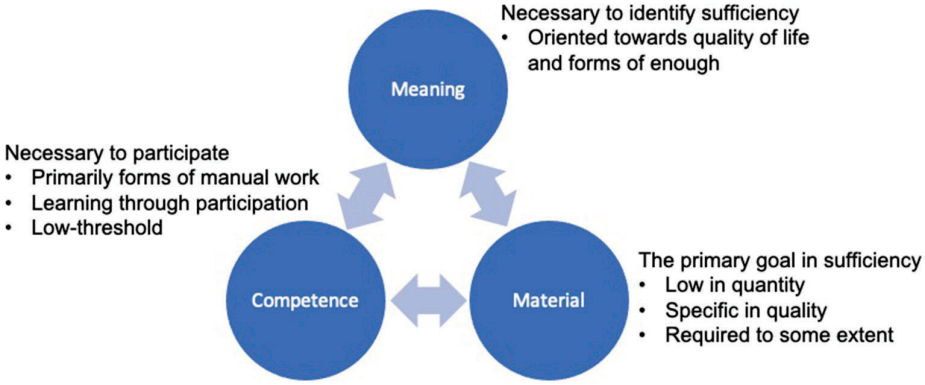

FIGURE 1
Locations of sufficiency in social practices (own depiction).

can be called sufficiency-oriented is quite complicated. However, this should be understood as a worthwhile analytical process when aiming for the sustainable and circular transition of our consumption and production system, as this allows us to focus on social practices that:

1) Have environmental potential in themselves by actually reducing the material base rather than just hoping to do so,
2) Share meanings that are relevant for consumption transitions, e.g. slowness, environmentalism, anti-consumerism, and hence have the potential for positive network effects, and
3) Build a knowledge and skill base that enables practitioners to participate in other sufficiency-oriented practices, which in turn can have positive network effects.

3. Methodology

3.1. Choice of case

To control for the above-mentioned theoretical postulations on how to identify sufficiency in social practices and further explore the phenomenon of sufficiency through the lens of social practice theory, the authors analyze the case of urban gardening (Hacking, 1992). The focus is on a single case as the research design itself is being tested. However, further studies might want to compare multiple cases or perform analyses in combination with longitudinal or retrospective studies, depending on the specific interests (Flick, 2021).

The case focused on is the Farmbox,[2] a more technically sophisticated urban garden involving hydroponic farming and aquafarming in symbiosis (an aquaponic system). This case was chosen as the result of a longer process as a part of the authors' work on a transdisciplinary project in the real-world laboratory of Wuppertal, a large city in Germany (Schneidewind et al., 2018).

First, the authors talked to the organizers of the "Aufbruch am Arrenberg" ("Departure on the Arrenberg") neighborhood association. The civic initiative is extremely active in the field of bottom-up collaborative urban development and neighborhood activities that focus on sharing, sustainability, and achieving a good life. Arrenberg is the name of the city district. As the initiative was already a project partner, the authors wanted to find a common interest for a study to boost urban sustainable initiatives. The Aufbruch am Arrenberg initiative is organized into three thematic fields: energy, mobility, and food. They also have some smaller projects categorized under "miscellaneous." As there was no mobility project with a current, real impact on everyday life, we disregarded that field. An energy-related project was discussed but later discarded when the funding was canceled. Food and other projects were more promising as they focus more on short-term, real-life actions rather than long-term, political engagements. This is in line with Lettenmeier (2018), who discussed the high potential for environmental savings and upscaling in the food sector because dietary choices can be made again every day.

The authors then organized an online workshop, inviting people involved in any food-related or other projects within the Arrenberg initiative. Table 1 provides an overview of the projects represented. One goal of the workshop was to gain a better understanding of each project and how they are organized to select one for in-depth analysis.

We chose the Farmbox project for further analysis as this was one of only two activities that was attended by several people. The other group was soon disregarded as everything had to be organized online (due to the COVID-19 pandemic), and they were an elderly, tech-averse group who already struggled with attending the online workshop and failed to complete the

2 https://arrenberg.app/projekte/die-farmbox/

10.3389/frsus.2022.1008165

TABLE 1 Projects represented at the online workshop.

Project	Description	Number of participants	Sustainability focus
Food sharing	Saving food from grocery stores and bakeries and sharing it with the public	4	Environment and society
Farmbox	Aquaponic system to grow food	4	Environment
Open restaurant day	People opening their private kitchens to the public for one day to meet and eat	1	Society
The taste of my childhood	Mainly migrants serving traditional food to the general public	1	Society
Free barber shop	Providing free shaves, fun and food to destitute people	1	Society
Clothes swap	Quarterly shop to donate or get clothes for free	1	Environment

surveys. The workshop took place in December 2020, followed by interviews in the Fall of 2021.

The Farmbox project was primarily managed by four people and was located next to a busy bike lane and café. The Farmbox is quite small (a trailer), so it is more of a test facility and place to learn about alternative ways of farming (teaching passers-by, too) and not a means of producing significant amounts of food (in a later project, some of the group scaled up this urban farming idea and provided proof of concept to build an aquafarm on an economically feasible level in the city). This special kind of garden attracted various people from different backgrounds. Three of the participants were men and one woman, all in their thirties. One participant, a biology student, who the others called the "walking biology encyclopedia," was already an experienced gardener, active in several gardening projects. For others, gardening was a new experience.

3.2. Data collection and analysis

The data collection was based on the principle of zooming in on and zooming out from social practices (Nicolini, 2009). The objective was to learn about the social (proto-) practices themselves (zooming in) to determine what was necessary for participation, what meanings the social practices had, and whether they inherited sufficiency principles, etc., as well as how they are integrated into the seamless web of social practices in daily life (zooming out, see Suski et al., 2021 for a framework on how to use this zooming duality in environmental assessments). A range of data collection methods was used for various dimensions of social practices (material, competence, and meaning) and at different points in time (current vs. at the beginning). In addition to this, the authors had intended to conduct group work for collective narratives and individual data collection as a contrasting, more personal form of narration. Table 2 provides an overview of the data collection methods used and what they each covered. The data collection was intended not only to provide data for this article but also for the work of others (focusing on social cohesion and social capital as well as a quantitative environmental assessment). Here, the focus was on the parts crucial for this article, but other parts were also mentioned to provide a full picture of what actually happened.

TABLE 2 Overview of data collection methods used and what they covered.

Method of data collections	Time	Dimensions of social practices covered	Zoom
Survey 1	Late 2020	Meaning and material	In (meaning) Out (material)
Online workshop	Late 2020	Competences	In
Survey 2 (timetables)	Late 2020	Material	Out
Interviews	Late 2021	Meaning	In and out

First, the authors conducted an online workshop with eleven participants in late 2020, which was accompanied by two surveys, one at the beginning to capture socio-demographic information and general information regarding the participants' personal lifestyles and one afterward to learn about the structure of their daily lives. The first survey asked the participants for:

- Socio-economic data (age, gender, income, profession/job, and education),
- Their role in the "Aufbruch am Arrenberg" initiative (the social practices they participated in, their motivation for participating in the project), and
- General information on private consumption (dietary information and hobbies).

The rationale behind this initial brief survey, which took around 5 min, was to gather some hard facts efficiently without interference. The motivation to participate was of the utmost importance for this article so that the authors could compare the responses with those from the interviews conducted later on where the interviewees described how they became involved in the project. This allowed the authors to make comparisons regarding different times in their engagement. The decision was taken to conduct this survey at the beginning because longer

TABLE 3 Overview of interviewees involved in the Farmbox.

Interviewee background	Main role	Length of interview
Biology student	Everything biology-related	40 min
Gastronomy manager	Artificial light	62 min
Designer	Public relations	64 min
Emergency paramedic	Handyman	54 min

group discussions on environmental protection, inclusive of living in the neighborhood, gentrification, etc., may have altered some of the responses.

The workshop aimed at gaining a broad picture of Arrenberg itself, its people, and the organized activities; in other words, the setting. The skills and materials of the social (proto-) practices were also captured.

The workshop was organized using the zoom online video call platform and online whiteboards (Google Jamboard), which were prepared beforehand. This not only allowed the participants to talk to and see each other but also to work collaboratively as in offline meetings. The whole session took 90 min. The participants captured the results themselves on the whiteboards in the form of text boxes, sticky notes, and drawings. The process was divided into three parts consisting of the following tasks:

1) Explain what you do in the Farmbox/food sharing etc. in such a way that someone else could do the same work afterward. This zoomed in on the skills, knowledge, and materials needed to perform the social practice.
2) Draw a map of how you are connected to each other (less relevant for this article) and the kind of people you are looking for to participate.
3) Show (on a shared map of the district) and describe important places in your daily lives. This zooming-out activity aimed to generate a general picture of how important the Arrenberg quarter is to the participants, which may imply sufficiency in mobility and satisfaction with their living environment. It was shown that this was less relevant for the Farmbox project because for some reason they were the only group who mainly lived outside the Arrenberg quarter.

A further online survey regarding social practices structured according to time and space (Røpke and Christensen, 2012) was conducted afterward by filling out timetables for an ordinary week and travel activities over the last year. This aimed at capturing material consumption, but it was less relevant for this article.

The semi-structured interviews conducted in late 2021 with the four Farmbox practitioners were most relevant for this article. The interviews were conducted during online video calls and were recorded. Table 3 provides the specifics of the interviews and interviewees. Each interview was structured into three main parts. The objectives and some sample questions can be seen in Table 4.

TABLE 4 Structure and goals of the semi-structured interviews.

Thematic topic	Objective	Questions (examples)
Description of what they personally do at the Farmbox and why.	Personal motivation and background for participation. The meaning of "Farmboxing" (zooming in).	Tell me again what you do here in Arrenberg and how you came to be here. What do you tell your friends about why you do this? What keeps you motivated when you are annoyed or face barriers?
Life in the Arrenberg quarter and, if they lived somewhere else, how this relates to their own living environment.	Exploring the setting in which the daily social practices occurred.	Tell me about life in Arrenberg. When friends from other cities visit, do you show them around Arrenberg? What do you do here then? Can you take something from life in Arrenberg back to your living environment or are these two completely separate worlds?
Consumption in everyday life (food, mobility, leisure, travel).	Meanings of other social practices in order to look for similarities with Farmboxing (zooming out).	What role does nutrition play in your everyday life? How do you source your food? Tell me how you get around in everyday life. Where will your next holiday be after Covid-19? What else do you like to do in your spare time besides the Farmbox? What do you consider important to have or achieve in your free time?

While the second survey already provided data on what the participants did and how often, this part of the interview was intended to provide information on the meaning of their consumption patterns. This is important as the meanings of social practices are always in competition with individual meanings. For example, the authors wanted to know why the interviewees avoided flying to go on holiday. This allowed the

social practice of "Farmboxing" to be connected to other social practices through shared meanings. This requires a level of self-awareness or reflective thinking and articulation. This presented certain challenges when it came to regional farming of products the interviewees bought at markets as they often could not articulate why regional production was so important to them, but rather just repeated that it was.

Prior to the interviews, the authors did not state that they are especially interested in the environmental aspects of what they were doing, just that they were interested in what the interviewees were doing. However, as the authors' names can easily be linked to environmental topics by doing a quick Internet search, they asked if the interviewees knew what we were working on, especially if the authors felt that the interviewees were really pushing environmental topics. None of them knew and they were interested to hear what it was all about. However, it is widely known in Wuppertal that the Wuppertal Institute works on various topics relating to sustainability, so the authors suspect that the participants had some idea of their areas of interest. This was also suggested by the fact that the interviews were very casual in style, implying familiarity and trust, perhaps based on a mutual interest in the topics of sustainability and environmentalism. Several cooperation projects have already been conducted between the Wuppertal Institute and the University of Wuppertal on the one side, and the Aufbruch am Arrenberg initiative on the other. Even though the interviewer had no previous history of involvement in such projects, this might have helped indirectly. This level of trust and openness was further supported during the interviews, helping to gain insightful answers on the interviewees' individual meanings and the meanings of the social practices they participated in. Here, it was helpful that the interviewer also grew food in her garden.

All these research activities were conducted during COVID lockdowns, so the authors tried to address irregularities in their routines, e.g., by asking what their first holiday after the COVID restrictions would be like. The interviews were conducted online, recorded, and transcribed.

The interviews were transcribed (clean read) and analyzed by conducting a qualitative content analysis (Mayring, 2014). As the authors were interested in the meanings of social practices and individual motivations to identify sufficiency and how it connects various social practices, the focus was exclusively on content that discussed such aspects. This means that the authors gathered all the meanings expressed by the interviewees and only later tried to identify the ones that were sufficiency-related. As there was no prior set of expected meanings of social practices in everyday life, a category system was developed inductively. As the category system grew with each interview, two runs were conducted with two different authors of this article to analyze the material. As the meanings are contextualized (meanings of specific social practices), the coding unit was a phrase.

4. Results and discussion

4.1. Zooming in on Farmboxing

At first glance, urban gardening, especially taking care of hydroponic and aquaponic systems, does not necessarily appear to be a sufficiency-oriented social practice. It is more directly linked to CE strategies such as reuse and recycling as nutrients and water run in circles between the two systems. From a technical perspective, sufficiency comes into play as hydroponic farming avoids using soil as the medium in which plants are grown and substitutes this with water. Data from the online workshop provided quite a broad picture of what the Farmbox project was all about. The authors summarized three general themes in terms of meanings that can be associated with "Farmboxing": *environmentalism*, *teaching and learning,* and *community*.

4.1.1. Environmentalism

While listing the requirements to participate in the Farmbox during the workshop, several people stated that motivation was necessary, though without clarifying what motivated them exactly ("Don't forget why you are doing this," "Motivation is important, be there regularly, no other basic requirement," or "The main requirement: be up for it, be interested."). However, they also vaguely stated that doing the work paid off. For instance, one participant explained: "Go the extra mile and you soon notice the benefit."

From the interviews, the authors learned that this vagueness of meaning could be linked to very different initial, individual motivations. While the biologist saw the environmental potential ("Using the same amount of effort, we can work in a more nature-friendly and environmentally friendly way that is also more effective and more efficient."), others reported an initial economic interest or just an interest in doing manual work in their free time. However, this initial motivation quickly grew to include the idea of environmental protection.

One person stated that, until recently, they had no connection whatsoever to topics regarding sustainability, but that this had changed since they started gardening in the Farmbox project. The reason for getting into urban farming was economic interest, as the participant saw, working in gastronomy, an opportunity to reduce the price of basil through hydroponic farming.

The participant explained: "But there, too, I saw the economic factor quite blatantly. So, I knew we had a problem, the curve in the price of basil. I want to make a flat line out of it. And that's how I sort of got into sustainability and Close the Loop and the circular economy. And so, I fell in love with shock." (Close the Loop refers to a project where the participants conducted a proof of concept to scale up the Farmbox.).

This growth into the sphere of environmentalism was also shared by another interviewee, jumping abruptly from a description of quality free time to environmentalism:

> "Everything is very technical, high-tech, a lot of things can be computer-controlled and IoT monitored. And that, for example, is actually what attracts me so much about it, this technical playfulness. We men turn seven, and after that we just grow, and we are children until the end, and that's a very big point I have to say, and simply because of that we dealt with sustainability a little bit at the beginning; you knew about it, you knew what was behind it, a little bit, but not so exactly yet either. And of course, this has been deepened by the Aufbruch am Arrenberg initiative and especially by the Farmbox project, and meanwhile, it has also become part of our everyday life."

This development toward more idealistic meanings can also be seen in the answers to the survey question asking participants to complete the sentence "Motivation: I participate in the activity because…." They all sounded very ambitiously sustainable, stating an interest in bottom-up urban development, local sustainability, climate neutrality, and collaborative engagement. However, when describing how they got into gardening in the interviews, they sounded very different. One stated that they always liked working manually with and on technical equipment but did not have a workshop at home to do so. The student reported that they were looking for a place to complete a mandatory internship (later it was made clear that the university would not accept the Farmbox as an internship, but this did not stop the student from participating). The participant who worked in gastronomy reported that they were not allowed to try hydroponic basil farming in the restaurant, so they had looked for another place to play around with the concept and test the technical aspects of it, taking a deep dive into the physics of light and its role in growing plants. The fourth participant came into contact with urban gardening and the Farmbox project during a project for their master's degree course.

4.1.2. Teaching and learning

Another aspect of the Farmbox project was the setting and its integration into city life. In the description of the Farmbox during the online workshop and in the interviews, it was mentioned several times that explaining their activities to passers-by, teaching science to ordinary people, and seeing that the project was considered an important task, was very rewarding ("As soon as somebody enters the Farmbox, they leave everything behind," "And we really used it to take people by the hand and walk them through the Farmbox to show them how it works. [..] And that was extremely enjoyable, because I'm here and I really like explaining things," "So, on the one hand, we want to gain a bit of experience, but also to inform on the other hand, to look at the whole thing as an extracurricular place of learning. And yes, in principle it is a learning and communication object.").

In addition to reaching out to other people external to the Farmbox and teaching them, learning things themselves was pointed out as well ("The knowledge that we have generated there, the practical experience that we have gained, I think we will also take much of that with us to Gut Einern." [Gut Einern is a newly-developed sustainable neighborhood project at a different location in Wuppertal founded by people from the Arrenberg area, one aspect being sustainable urban farming. Some of the people from the Farmbox project subsequently got involved in Gut Einern], "And also the learning, so X has really dug into the topic of plants, especially artificial light and things like that. […] that's why I think that personal learning and all the aspects I mentioned are definitely present in all of us," "[…] where everyone really benefited was the know-how and no, no real monetary amount").

It is hard to tell, but there is often no clear distinction between learning and teaching as they both involved the excitement of newly-gained knowledge. That is why these are summarized as one central meaning of "Farmboxing."

4.1.3. Community

Finally, the aspect of community was pointed out by the participants. This can be traced back to its origin in the Aufbruch am Arrenberg project, which is based on an open neighborhood community. When asked about their motivation to continue working on the Farmbox project, they replied: "And just to stay in contact with the people and also to somehow work together with the Farmbox group," or "On the one hand, of course, the people, and because somehow everything has developed in such a sustainable, yes, it is a bubble sometimes, sustainable direction, which is extremely, extremely exciting," or "I am a very social person. I really, really like being around people, but also looking for common ground with people." The community aspect, however, was discussed less often compared to environmentalism and teaching and learning. The reason for this was unclear, and the authors cannot conclude that community was less important. It is probably just less present as an articulated topic.

In summary, it can be stated that the Farmbox project was a time-consuming social proto-practice that focused on piling up and sharing intangible assets such as knowledge of environmental food production and the pure joy of collaborative work. The material products aimed for were simply basic food, hopefully, produced in a resource-saving manner. There was no high competence threshold to participate in the Farmboxing practice as the only requirement was motivation. Expertise was gained over time and the yield was of secondary importance. As the Farmbox concept is a high-tech version of urban gardening, the necessary material base for implementing a

project similar to the Farmboxing project would be quite high (a container, pumps, photovoltaic panels, etc.), especially in relation to the low yield. The authors did not conduct a full environmental assessment comparing the Farmboxing concept to regular farming. Therefore, the conclusion can probably be drawn that, in this state of technological development, the Farmboxing concept is more resource-consuming. However, if the Farmboxing approach is seen as a specific aspect of living in an urban neighborhood focusing on the environment, community, and sharing knowledge, as is the case within the whole Aufbruch am Arrenberg project, a broader picture of how such a life evolves around "Farmboxing" is needed. This can be obtained by zooming out to see the whole potential.

4.2. Zooming out of Farmboxing

While zooming out of Farmboxing, a distinction has to be made between food-related and other social practices as Farmboxing is in itself food-related and, hence, has higher impacts in this consumption area.

4.2.1. Food-related social practices

The interviews showed that growing some food made the participants far more aware of seasonal and regional food production and the energy demand for vegetables that require external heating or transportation. In this way, the Farmboxing project is connected to food shopping. All four participants reported that they had stopped or reduced buying fruits and vegetables from faraway regions due to environmental concerns. In doing so, they fundamentally questioned the idea of all fruits and vegetables being available all year round (which leads to high energy demands for storage and to heat greenhouses), all day long (which leads to food waste in the evening), and from all over the globe (which leads to high transportation requirements). This negatively associated meaning of "über-availability," the availability of everything at all times without the fear of missing anything, was primarily linked to the social practice of shopping for food, as one interviewee said quite clearly:

> "I am simply of the opinion that a coconut that grows in North Africa cannot be flown to Central Africa to be removed from its shell, packed in plastic packaging and flown to Germany. I am simply of the opinion that this does not have to be."

Further stating:

> "So yes, if you think you have to have a coconut at all times, OK, then pay for it so that it shows up in some balance sheet somewhere. You can probably tell me a little bit more about that, but as long as that is the case, how can renunciation take place when everything is available and affordable in the supermarket? At the expense of some cross-subsidisation financing."

Another interviewee proved this point using their broader knowledge and experience of the topic of different seasons in Spain:

> "Absolutely right, but they will be heated. Yes, so even these greenhouses, houses in Spain will be heated at some point. And I don't think that's quite so justifiable in terms of energy. If you look at the half white cabbage, it probably wasn't heated, it's still standing until probably the middle of the month, can it be harvested, or was it harvested, or palm kale or green kale or something. Yes, it does relatively well without heating, in the fertiliser balance too. Whereas you have to supply the tomatoes and peppers with endless nutrients and energy."

Furthermore, the interviewee made clear how his own farming activities (not just the Farmbox project) were directly connected to shopping in supermarkets:

> "Yes, well, by seeing what's in my field and by seeing what's on offer in the supermarket, I can discriminate a bit and say okay, I haven't had peppers for 3 months now. Why should I buy them at Aldi?"

This seasonality of vegetables makes this sufficiency behavior easier for the interviewee, as it is always a temporal renunciation.

> "When I'm in the shop and I see a red pepper and I feel like eating a red pepper, but at the same time I know that if I eat this red pepper now, it's really not ecologically justifiable at all, I can put myself off by telling myself: okay, come on, then you'll just eat red peppers again from June."

Here we see a strong meaning of "enoughness" associated with farming and food shopping as the direct counterpart to the dominant über-availability.

4.2.2. Other social practices (mobility, leisure, and travel)

The meanings of environmentalism and enoughness were not as strong in other consumption areas. However, several social practices were reported after internal reflection. The following two quotes from different interviewees exemplify this:

> "But I just notice that when I tell people that I think it's totally cool to drive such a fast car and allow myself this luxury, but on the other hand I stand in front of the coconut shelves in the supermarket and say 'Oh, but that doesn't have to be there now', then I find myself thinking that somewhere the finger has to point in the other direction."

> "That really is schizophrenia. So, you really save your peppers here in winter and then still have the nerve to say, 'Ah well, we're going on a week's skiing holiday to Austria and we're all going there by car."

This demonstrates the tension inherent to connections of meanings between social practices. What is remarkable in the second quote above is that driving fully packed cars from Germany to Austria for one's main holiday is regarded as insane compared with other sufficiency-oriented social practices engaged in by the participants. Surprisingly, none of them were planning to take flights in the foreseeable future or had taken them in the last couple of years. One even said that they planned to take a flight but decided not to when they saw how cheap the tickets were and realized that something is fundamentally wrong when faraway places are too available.

Another participant said that they had only left Europe once for a business trip to Istanbul and struggled to find good reasons for such long flights:

> "Exactly, but never before actually leaving Europe. So, all the time I think of Asia once. [..] And I was such a big Lord of the Rings fan at the time and I thought the landscape was so great, but then I went to Norway [..], and you can compare the landscape there quite well at least with the New Zealand landscape I am familiar with from pictures. And that's just it, there are so many countries besides Spain, Italy, and France that I think are also very, yes, worth exploring in Europe."

Luckily, these observations are in opposition to other research, where it has been observed that even environmentally aware people forget all about the environment on their holiday trips (Anciaux, 2019). While we have no data that can explain why our sample is more environmentally aware when it comes to traveling, we hypothesize that regional aspects of environmentalism learned through the Farmboxing practice led to this specific sufficiency-oriented mindset of "the whole world is not accessible to everyone, neither for coconuts nor for holidays." Figure 2 gives a rough and abbreviated overview of the newly emerging network of social practices due to the emergence of Farmboxing. As Farmboxing is not yet fully established, many links within Farmboxing and to other social practices are still considered weak.

Upon closer examination of the reports on social practices referred to simply as sufficiency-oriented, in this chapter, some difficulties arise in the field of food purchasing. Here, sufficiency can be found in the meanings (über-availability, regionality, and environmentalism), the competences (knowledge of global value chains in the food sector and what to look for in the supermarket), and in the materials, as some products are excluded from the act of purchasing. However, it is not quite clear if overall, life-cycle-wide, material demand is really reduced. Transport distances are not necessarily that environmentally relevant. A study has shown that apples from Germany can have a higher environmental impact when purchased in Germany than apples from New Zealand, depending on the season (this is due to the energy demand of cooling apples for many months, Wuppertal Institute, 2016). Additionally, when intercontinental vegetables are replaced by regional meat, nothing is gained (Poore and Nemecek, 2018). However, our study did not go deep enough to observe food purchasing over a longer period of time. Seasonality was reported by some interviewees as a factor in their grocery shopping, but further insight was lacking. It was only observed that the two participants with longer histories of environmental lifestyles and broader competences in this regard were more committed to sufficiency as they were vegan and pescetarian. However, the other two also reported a reduction in the consumption of animal products in recent years.

The case of sufficiency is surprisingly clear for the reported holiday trips. The travel plans consisted of the image of beauty at closer proximity and the idea of enough (Norway is sufficient, no need to go to New Zealand as a European), the skills to individually plan holiday trips that meet personal needs and reduce the material base through shorter distances. Here, it must be pointed out that sufficiency is relative since traveling to Norway (from Germany) as a substitute for New Zealand landscapes is a reduction, but with the potential for even further reduction. At least refusing to fly for private activities was very well developed.

In summary, the authors observed that sufficiency-oriented social practices can emerge, develop, or be successful in recruiting carriers as a result of participating in social practices that inherit sufficiency-oriented meanings but are not necessarily sufficient in terms of material (due to the high material demand of the Farmbox project).

5. Conclusion

The authors provided a novel approach to address CE strategies with high environmental potential that evolved around the concept of refusing, rethinking, and reducing by shifting the perspective from the consumer to social practices. In doing so, the concept of sufficiency was introduced as a key concept in the CE discourse, which is necessary if environmental pressure is to be substantially reduced by CE and the transformation of our production and consumption system is to be taken seriously. To be very clear, the authors state that there will be no sustainable circular economy without sufficiency as a central principle. In this way, refusal, rethinking, and reduction must be understood as sufficiency strategies and not limited to product design concepts.

We were confronted with an interesting case where there was no high threshold preventing contact with radical new logic, but where such radicality quickly evolved, the concept of über-availability was brought into question and replaced

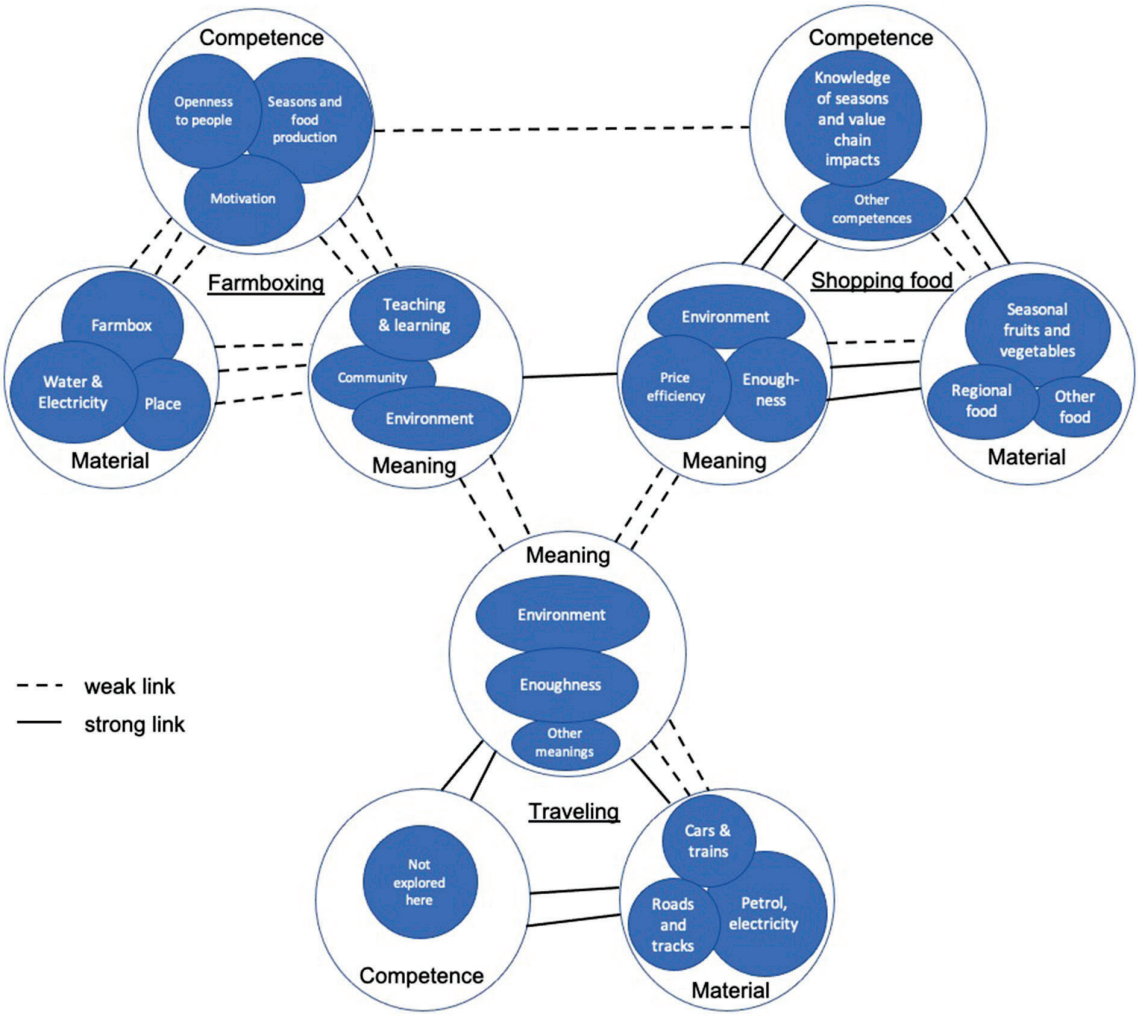

FIGURE 2
Extract from a network of social practices linked to Farmboxing through shared meanings and competences. Weak links are newly developed or contested, strong links are more established and less contested. The number of links is exemplary and materials, competences, and meanings are not exhaustive.

with enoughness. This is what makes the explicit consideration of sufficiency so interesting for CE approaches from a transition perspective: there are intersections with alternative and existing logic. The authors observed that sufficiency found its way into the lifestyles of the participants, even though it was questionable whether the Farmboxing approach studied actually reduces overall material demand and, hence, counts as sufficiency. This shows the importance of zooming out from social practices. The study showed that introducing sufficiency in a low-threshold manner simply by providing a public space for gardening activities can be successful as its radicality is tamed and it can be linked to the dominant logic (there is a long history of allotments in Germany). The upscaling potential of the Farmboxing concept is then that it still challenges the dominant logic and thus brings them into tension.

All this, however, was a very small case, and generalization would be inappropriate. There are many aspects that this study was unable to address. While the authors were able to identify some relevant factors, it was unclear how they worked together. For example, the importance of the social setting is unclear: how interchangeable is the presence of the "walking biology encyclopedia" who brought much environmental knowledge into the group? How would sufficiency spread into the lifestyles of the participants if the case had not concerned agriculture, which has strict rules of seasonal availability, but rather mobility or food waste? What sufficiency-oriented meanings show high potential to connect to other social practices? Here, more

empirical work is needed. The time to conduct such research seems right as the war in Ukraine, rising energy and food prices, and stressed supply chains overall have led to even greater demand for strategies and policies to reduce our resource dependencies. As this is congruent with the proposed goals of CE advocates, both topics, sufficiency and CE, should finally be merged.

As a life-cycle-wide environmental assessment was not conducted and the lifestyles described therefore could not be quantitatively evaluated, especially when it came to groceries, this presented problems in the analysis. Therefore, the authors have already planned a follow-up study that combines qualitative and quantitative analyses of different bottom-up neighborhood activities by utilizing social practice theories and life cycle assessments. Comparative and longitudinal studies might help to further explore the impact of interventions.

The authors also propose future research that delves deeper into social practice theories to understand and describe how opposite meanings are connected. What is referred to in this article as "über-availability" and what other studies have already called "enoughness" seem to be counterparts.

In this article, the authors have avoided coining clear, new definitions of reuse, rethink, and reduce, but they think that this should be done in the future by providing empirical data on the logic of such strategies and exemplifying this with meanings in observed social practices.

Finally, researchers are also welcome to explore the potential of social practice theories for other CE strategies as social practices are not limited to private consumption.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

Author contributions

PS, AP, and MS developed the idea for the article. PS performed the empirical analysis, data collection, wrote most of the original draft, and the revised manuscript. AP contributed to the idea of sufficiency as a transition strategy. MS supervised the writing process. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Alexander, S., and Ussher, S. (2012). The voluntary simplicity movement: A multi-national survey analysis in theoretical context. *J. Consum. Cult.* 12, 66–86. doi: 10.1177/1469540512444019

Anciaux, A. (2019). "On holidays, i forget everything… even my ecological footprint": sustainable tourism through daily practices or compartmentalisation as a keyword? *Sustainability* 11, 4731. doi: 10.3390/su11174731

Augenstein, K., Bachmann, B., Egermann, M., Hermelingmeier, V., Hilger, A., Jaeger-Erben, M., et al. (2020). From niche to mainstream: the dilemmas of scaling up sustainable alternatives. *GAIA Ecol. Persp. Sci. Soc.* 29, 143–147. doi: 10.14512/gaia.29.3.3

Bocken, N. M. P., Niessen, L., and Short, S. W. (2022). The sufficiency-based circular economy—an analysis of 150 companies. *Front. Sustain.* 3, 899289. doi: 10.3389/frsus.2022.899289

Bringezu, S., and Bleischwitz, R. (2009). *Sustainable Resource Management: Global Trends, Visions and Policies*. London: Greenleaf, Sheffield, UK.

Brinken, J., Trojahn, S., and Behrendt, F. (2022). Sufficiency, Consistency, and Efficiency as a Base for Systemizing Sustainability Measures in Food Supply Chains. *Sustainability* 14, 6742. doi: 10.3390/su14116742

Camacho-Otero, J., Boks, C., and Pettersen, I. (2018). Consumption in the Circular Economy: A Literature Review. *Sustainability* 10, 2758. doi: 10.3390/su10082758

Corvellec, H., Stowell, A. F., and Johansson, N. (2022). Critiques of the circular economy. *J of Industrial Ecology* 26, 421–432. doi: 10.1111/jiec.13187

Ehnert, F., Kern, F., Borgström, S., Gorissen, L., Maschmeyer, S., Egermann, M., et al. (2018). Urban sustainability transitions in a context of multi-level governance: a comparison of four European states. *Environ. Innov. Soc. Trans.* 26, 101–116. doi: 10.1016/j.eist.2017.05.002

El Bilali, H. (2019). The multi-level perspective in research on sustainability transitions in agriculture and food systems: a systematic review. *Agriculture* 9, 74. doi: 10.3390/agriculture9040074

Ellen MacArthur Foundation (2014). *Towards the Circular Economy 3 - Accelerating the Scale-Up Across Global Supply Chains*. Cowes: Ellen MacArthur Foundation

European Commission (2020). *A New Circular Economy Action Plan For a Cleaner and More Competitive Europe*.

Fischer, C., Grießhammer, R., Barth, R., Brohmann, B., Brunn, C., Heyen, D. A., et al. (2013). *When Less is More. Sufficiency: Terminology, Rationale and Potentials (Working paper)*.

Flick, U. (2021). *Qualitative Sozialforschung: eine Einführung, 10. Auflage, Originalausgabe. ed, Rororo Rowohlts Enzyklopädie*. rowohlts enzyklopädie im Rowohlt Taschenbuch Verlag, Reinbek bei Hamburg.

Fuchs, D., Sahakian, M., Gumbert, T., Giulio, A. D., Maniates, M., Lorek, S., et al. (2021). Consumption Corridors: Living a Good Life within Sustainable Limits. New York, NY: Routledge

Fuenfschilling, L., and Truffer, B. (2014). The structuration of socio-technical regimes—Conceptual foundations from institutional theory. *Res. Policy* 43, 772–791. doi: 10.1016/j.respol.2013.10.010

Geels, F. W., and Schot, J. (2007). Typology of sociotechnical transition pathways. *Res. Policy* 36, 399–417. doi: 10.1016/j.respol.2007.01.003

Gossen, M., and Kropfeld, M. I. (2022). "Choose nature. Buy less." Exploring sufficiency-oriented marketing and consumption practices in the outdoor industry. *Sust. Prod. Consumpt.* 30, 720–736. doi: 10.1016/j.spc.2022.01.005

Gossen, M., Ziesemer, F., and Schrader, U. (2019). Why and how commercial marketing should promote sufficient consumption: a systematic literature review. *J. Macromarket.* 39, 252–269. doi: 10.1177/0276146719866238

Hacking, I. (1992). 'Style' for historians and philosophers. *Stud. History Philos. Sci.* 23, 1–20. doi: 10.1016/0039-3681(92)90024-Z

Hampton, S., and Adams, R. (2018). Behavioural economics vs social practice theory: perspectives from inside the United Kingdom government. *Energ. Res. Soc. Sci.* 46, 214–224. doi: 10.1016/j.erss.2018.07.023

Huber, A. (2017). Theorising the dynamics of collaborative consumption practices: a comparison of peer-to-peer accommodation and cohousing. *Environ. Innov. Soc. Trans.* 23, 53–69. doi: 10.1016/j.eist.2016.12.001

Hüttel, A., Ziesemer, F., Peyer, M., and Balderjahn, I. (2018). To purchase or not? Why consumers make economically (non-) sustainable consumption choices. *J. Clean. Prod.* 174, 827–836. doi: 10.1016/j.jclepro.2017.11.019

IGES (2019). *Aalto University, Degree Lifestyles: Targets and Options for Reducing Lifestyle Carbon Footprints. Technical Report*. Hayama: Institute for Global Environmental Strategies.

Jaeger-Erben, M., Jensen, C., Hofmann, F., and Zwiers, J. (2021). There is no sustainable circular economy without a circular society. *Res. Conserv. Recycl.* 168, 105476. doi: 10.1016/j.resconrec.2021.105476

Jungell-Michelsson, J., and Heikkurinen, P. (2022). Sufficiency: a systematic literature review. *Ecol. Econ.* 195, 107380. doi: 10.1016/j.ecolecon.2022.107380

Kemp, R., Schot, J., and Hoogma, R. (1998). Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management. *Technol. Anal. Strat. Manage.* 10, 175–195. doi: 10.1080/09537329808524310

Kropfeld, M. I. (2022). Lifestyles of enough exploring sufficiency-oriented consumption behavior from a social practice theory perspective. *J. Consum. Cult.* 15, 146954052210950. doi: 10.1177/14695405221095008

Kropfeld, M. I., and Reichel, A. (2021). "The business model of enough: value creation for sufficiency-oriented businesses," in *Business Models for Sustainability Transitions*, eds A. Aagaard, F. Lüdeke-Freund, P. Wells (Cham: Springer International Publishing), 163–189.

Lahusen, M., Ritzmann, S., Sametinger, F., Joost, G., and Brischke, L. A. (2016). *Mixing up Everyday Life - Uncovering Sufficiency Practices Through Designerly Tools*. Brighton: Design Research Society.

Lettenmeier, M. (2018). *A Sustainable Level of Material Footprint. Benchmark for Designing One-Planet Lifestyles*. Aalto: School of Art and Design.

Lettenmeier, M., Liedtke, C., and Rohn, H. (2014). Eight tons of material footprint—suggestion for a resource cap for household consumption in Finland. *Resources* 3, 488–515. doi: 10.3390/resources3030488

Loorbach, D., Wittmayer, J., Avelino, F., von Wirth, T., and Frantzeskaki, N. (2020). Transformative innovation and translocal diffusion. *Environ Innov Soc. Trans.* 35, 251–260. doi: 10.1016/j.eist.2020.01.009

Mayring, P. (2014). *Qualitative Content Analysis: Theoretical Foundation, Basic Procedures and Software Solution*. Klagenfurt: GESIS–Leibniz Institute for the Social Sciences.

McDonough, W., and Braungart, M. (2002). *Cradle to Cradle: Remaking the Way We Make Things, 1st Edn*. New York, NY: North Point Press.

Morseletto, P. (2020). Targets for a circular economy. *Res. Conserv. Recycl.* 153, 104553. doi: 10.1016/j.resconrec.2019.104553

Nicolini, D. (2009). Zooming in and out: studying practices by switching theoretical lenses and trailing connections. *Org. Stu.* 30, 1391–1418. doi: 10.1177/0170840609349875

Poore, J., and Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science* 360, 987–992. doi: 10.1126/science.aaq0216

Potting, J., Hekkert, M., Worrell, E., and Hanemaaijer, A. (2017). *Circular Economy: Measuring Innovation in the Product Chain (Policy Report)*. Hague: Planbureau voor de Leefomgeving.

Princen, T. (2005). *The Logic of Sufficiency*. Cambridge, MA: MIT Press.

Rabiu, M. K., and Jaeger-Erben, M. (2022). Appropriation and routinisation of circular consumer practices: a review of current knowledge in the circular economy literature. *Clean Res. Consumpt.* 7, 100081. doi: 10.1016/j.clrc.2022.100081

Raven, R. P. J. M. (2005). *Strategic niche management for biomass: a comparative study on the experimental introduction of bioenergy technologies in the Netherlands and Denmark* (Doctor of Philosophy). Industrial Engineering and Innovation Sciences, Eindhoven, Netherlands. doi: 10.6100/IR590593

Reckwitz, A. (2002). Toward a theory of social practices: a development in culturalist theorizing. *Eur. J. Soc. Theor.* 5, 243–263. doi: 10.1177/13684310222225432

Reike, D., Vermeulen, W. J. V., and Witjes, S. (2018). The circular economy: New or Refurbished as CE 3.0? — exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options. resources. *Conserv. Recycl.* 135, 246–264. doi: 10.1016/j.resconrec.2017.08.027

Retamal, M. (2019). Collaborative consumption practices in Southeast Asian cities: prospects for growth and sustainability. *J. Clean. Prod.* 222, 143–152. doi: 10.1016/j.jclepro.2019.02.267

Reuter, M. A., van Schaik, A., Gutzmer, J., Bartie, N., and Abadías-Llamas, A. (2019). Challenges of the circular economy: a material, metallurgical, and product design perspective. *Annu. Rev. Mater. Res.* 49, 253–274. doi: 10.1146/annurev-matsci-070218-010057

Røpke, I. (2009). Theories of practice — New inspiration for ecological economic studies on consumption. *Ecol. Econ.* 68, 2490–2497. doi: 10.1016/j.ecolecon.2009.05.015

Røpke, I., and Christensen, T. H. (2012). Energy impacts of ICT – Insights from an everyday life perspective. *Telematic. Inf.* 29, 348–361. doi: 10.1016/j.tele.2012.02.001

Rüdenauer, I., Gensch, C. O., and Liu, R. (2008). *Vergleich der Umweltauswirkungen und Kosten verschiedener*. Deutscher Medien Verlag GmbH: Wäschetrocknungssysteme.

Saheb, Y. (2021). *COP26: Sufficiency Should be First*. Buildings and Cities. Available online at: https://www.buildingsandcities.org/insights/commentaries/cop26-sufficiency.html (accessed December 15, 2022).

Sandberg, M. (2021). Sufficiency transitions: a review of consumption changes for environmental sustainability. *J. Cleaner Prod.* 293, 126097. doi: 10.1016/j.jclepro.2021.126097

Santarius, T., Bieser, J. C. T., Frick, V., Höjer, M., Gossen, M., Hilty, L. M., et al. (2022). *Digital* sufficiency: conceptual considerations for ICTs on a finite planet. *Ann. Tele commun.* 12, 1–9. doi: 10.1007/s12243-022-00914-x

Schneidewind, U., Augenstein, K., Stelzer, F., and Wanner, M. (2018). Structure matters: real-world laboratories as a new type of large-scale research infrastructure:

a framework inspired by giddens' structuration theory. *GAIA Ecol. Persp. Scie. Soc.* 27, 12–17. doi: 10.14512/gaia.27.S1.5

Schneidewind, U., and Zahrnt, A. (2014). *The Politics of Sufficiency: Making it Easier to Live the Good Life*. München: Oekom.

Schot, J., and Geels, F. W. (2008). Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. *Technol. Anal. Strateg. Manage.* 20, 537–554. doi: 10.1080/09537320802292651

Shove, E. (2003). Converging conventions of comfort, cleanliness and convenience. *J. Consum. Policy* 26, 395–418. doi: 10.1023/A:1026362829781

Shove, E. (2010). Beyond the ABC: climate change policy and theories of social change. *Environ. Plann. Econ. Space* 42, 1273–1285. doi: 10.1068/a42282

Shove, E. (2017). "Matters of practice," in *The Nexus of Practices: Connections, Constellations, Practitioners*, eds A. Hui, T. Schatzki, E. Shove (New York, NY: Routledge).

Shove, E., Pantzar, M., and Watson, M. (2012). *The Dynamics of Social Practice: Everyday Life and How it Changes*. London: SAGE. doi: 10.4135/9781446250655

Spangenberg, J. H., and Lorek, S. (2019). Sufficiency and consumer behaviour: From theory to policy. *Energy Policy* 129, 1070–1079. doi: 10.1016/j.enpol.2019.03.013

Speck, M. (2016). *Konsum und Suffizienz: eine empirische Untersuchung Privater Haushalte in Deutschland, Research*. Wiesbaden: Springer.

Speck, M., and Hasselkuss, M. (2015). Sufficiency in social practice: searching potentials for sufficient behavior in a consumerist culture. *Sust. Sci. Prac. Policy* 11, 14–32. doi: 10.1080/15487733.2015.11908143

Speck, O., Möller, M., Grießhammer, R., and Speck, T. (2022). Biological concepts as a source of inspiration for efficiency, consistency, and sufficiency. *Sustainability* 14, 8892. doi: 10.3390/su14148892

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., et al. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science* 347, 1259855. doi: 10.1126/science.1259855

Stengel, O. (2011). *Suffizienz: die Konsumgesellschaft in der ökologischen Krise, Wuppertaler Schriften zur Forschung für eine nachhaltige Entwicklung*. München: Oekom.

Suski, P., Speck, M., and Liedtke, C. (2021). Promoting sustainable consumption with LCA – A social practice based perspective. *J. Clean Prod.* 283, 125234. doi: 10.1016/j.jclepro.2020.125234

Von Wirth, T., Fuenfschilling, L., Frantzeskaki, N., and Coenen, L. (2019). Impacts of urban living labs on sustainability transitions: mechanisms and strategies for systemic change through experimentation. *Eur. Plan. Stud.* 27, 229–257. doi: 10.1080/09654313.2018.1504895

Warde, A. (2005). Consumption and theories of practice. *J. Consum. Culture* 5, 131–153. doi: 10.1177/1469540505053090

Welch, D., Keller, M., and Mandich, G. (2017). Imagined futures of everyday life in the circular economy. *Interactions* 24, 46–51. doi: 10.1145/3047415

Wuppertal Institute (2016). *Apfel ist nicht gleich Apfel - Ökologische and Soziale Auswirkungen von Äpfeln, Unter Berücksichtigung Unterschiedlicher Anbaumethoden*. Wuppertal: Wuppertal Institut.

Wynes, S., and Nicholas, K. A. (2017). The climate mitigation gap: education and government recommendations miss the most effective individual actions. *Environ. Res. Lett.* 12, 074024. doi: 10.1088/1748-9326/aa7541

Zwiers, J., Jaeger-Erben, M., and Hofmann, F. (2020). Circular literacy. A knowledge-based approach to the circular economy. *Cult. Org.* 26, 121–141. doi: 10.1080/14759551.2019.1709065

4 Publication C: LCA of urban sharing

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A quantitative environmental assessment of urban sharing was conducted, which aims at validating the newly developed social practice based LCA from chapter 2 and identify the environmental potential of urban sharing. Furthermore, an analysis of the conditions under which meanings of enough establish links between various social practices was conducted by including narrative approaches. As a novel way to conduct LCA, the social practice nexus of urban sharing is used as the system boundary, which includes shopping food, urban mobility and travelling. The results show, that the effect of urban sharing on other social practices across different consumption categories can substantially decrease the environmental burdens of daily life. Especially changing food patterns proof to be environmentally relevant. It shows, that doing LCA social practice informed, alters the modelling, by expanding the system boundaries and data collection in the life cycle inventory phase, which results in an illumination of environmental potential that would otherwise be overlooked. Identified narratives of place and change showed the importance of urban development and third places, to allow small emerging phenomena, such as sharing, to develop a transformative potential. For achieving sustainability by adopting circularity, this study shows that stakeholders should refocus on the sufficiency-oriented strategies of refuse, rethink and reduce and use interdisciplinary approaches, such as the proposed social practice based LCA, to assess environmental potentials, when transformative change is being expected.

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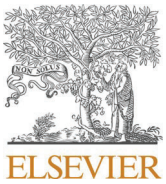

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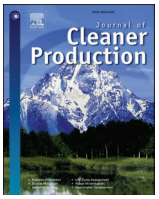

Life Cycle Assessment of Consumption Patterns – Understanding the links between changing social practices and environmental impacts

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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,

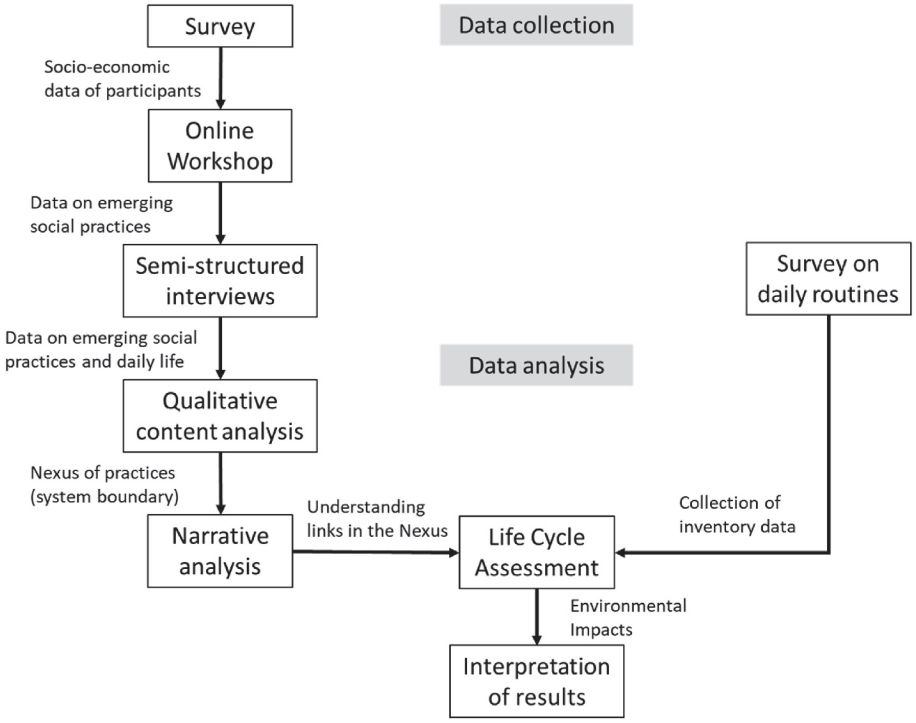

Fig. 1. Interdisciplinary research plan.

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	Show me roughly what you were doing in an average workday/ weekend in October 2020. Also
	leisure practices	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:

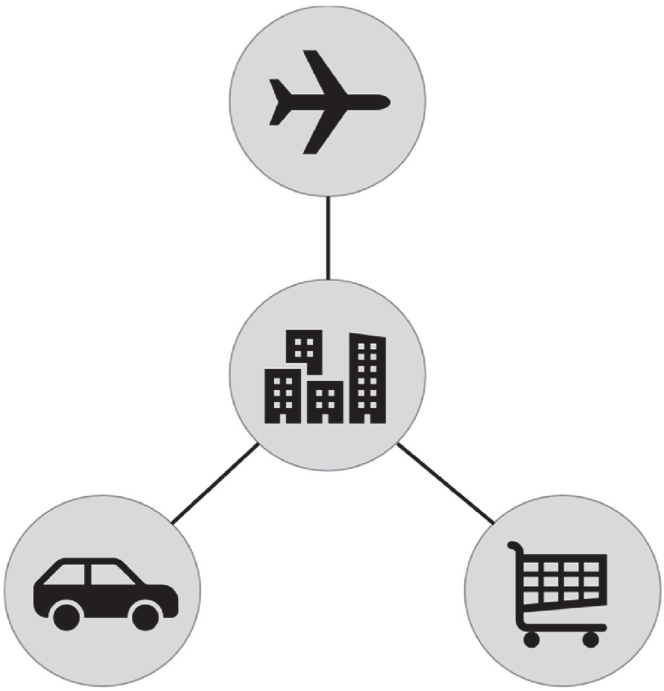

Fig. 2. Nexus of social practices: bottom-up neighbourhood practices connected to travelling, urban mobility and grocery shopping serving as the system boundary of the Life Cycle Assessment.

"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.

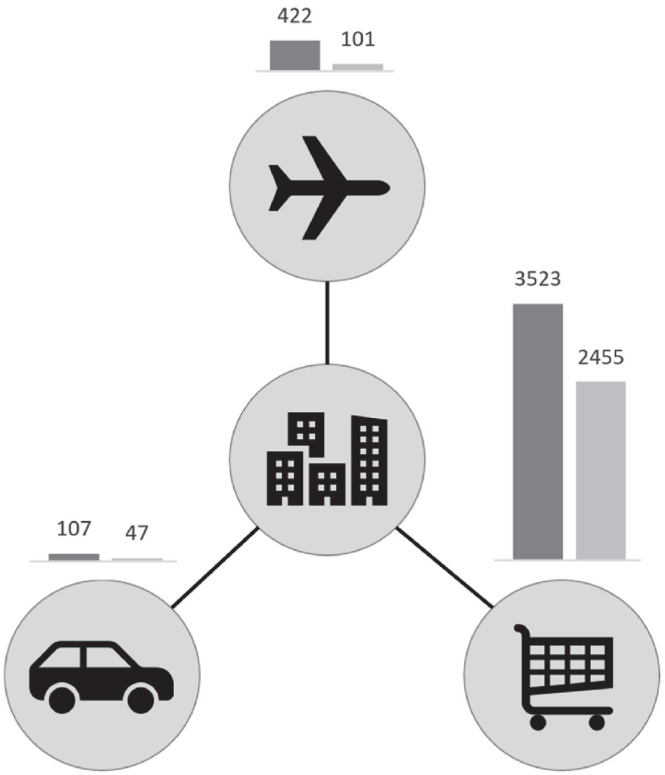

Fig. 3. Carbon Footprints in kg CO_2-eq. per person and year in the nexus of social practices. Darker bars represent the status quo, brighter bars represent changed social practices.

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

References

ADAC, 2023. Reisen nach Corona [WWW Document]. URL. https://www.adac.de/verkehr/standpunkte-studien/mobilitaets-trends/tourismusstudie-reisen-corona/, 7.18.23.

Augenstein, K., Bachmann, B., Egermann, M., Hermelingmeier, V., Hilger, A., Jaeger-Erben, M., Kessler, A., Lam, D.P.M., Palzkill, A., Suski, P., von Wirth, T., 2020. From niche to mainstream: the dilemmas of scaling up sustainable alternatives. GAIA - Ecological Perspect. Sci. Soc. 29, 143–147. https://doi.org/10.14512/gaia.29.3.3.

BDL, 2019. Wofür braucht es innerdeutschen Luftverkehr? URL. https://www.bdl.aero/de/publikation/wofuer-braucht-es-innerdeutschen-luftverkehr-2019/, 7.18.23.

Bianchi, M., Cordella, M., 2023. Does circular economy mitigate the extraction of natural resources? Empirical evidence based on analysis of 28 European economies over the past decade. Ecol. Econ. 203, 107607. https://doi.org/10.1016/j.ecolecon.2022.107607.

Bienge, K., Clausen, J., Suski, P., Schmitt, M., 2019. Ecological and socio-technical assessment of collaborative consumption: resource efficiency potentials. NachhaltigkeitsManag. Forum Sustain. Manage. Forum 27, 139–149. https://doi.org/10.1007/s00550-019-00489-7.

Borrello, M., Cembalo, L., D'Amico, V., 2023. Narratives to revert overconsumption: human-nature interdependence and Circular Economy. Agric. Econ. 11, 19. https://doi.org/10.1186/s40100-023-00259-6.

Borrello, M., Cembalo, L., D'Amico, V., 2022. Redefining wellbeing and normality: circular consumption beyond the low hanging fruit. Resour. Conserv. Recycl. 179, 106034. https://doi.org/10.1016/j.resconrec.2021.106034.

Buhl, J., Acosta, J., 2016. Indirect effects from resource sufficiency behaviour in Germany. In: Rethinking Climate and Energy Policies - New Perspectives on the Rebound Phenomenon.

Calisto Friant, M., Vermeulen, W.J.V., Salomone, R., 2023. Transition to a sustainable circular society: more than just resource efficiency. Circ.Econ.Sust. https://doi.org/10.1007/s43615-023-00272-3.

Calisto Friant, M., Vermeulen, W.J.V., Salomone, R., 2021. Analysing European Union circular economy policies: words versus actions. Sustain. Prod. Consum. 27, 337–353. https://doi.org/10.1016/j.spc.2020.11.001.

Caspers, J., Süßbauer, E., Coroama, V.C., Finkbeiner, M., 2023. Life cycle assessments of takeaway food and beverage packaging: the role of consumer behavior. Sustainability 15, 4315. https://doi.org/10.3390/su15054315.

Castelo, A.F.M., Schäfer, M., Silva, M.E., 2020. Food practices as part of daily routines: a conceptual framework for analysing networks of practices. Appetite 157, 104978. https://doi.org/10.1016/j.appet.2020.104978.

Chabay, Koch, Martinez, Scholz, 2019. Influence of narratives of vision and identity on collective behavior change. Sustainability 11, 5680. https://doi.org/10.3390/su11205680.

Corona, B., Tunn, V.S.C., Van Den Broek, K.L., 2024. Integrating consumer behaviour into the environmental assessment of circular packaging: a scoping review. Int. J. Life Cycle Assess. 29, 80–98. https://doi.org/10.1007/s11367-023-02218-1.

Corvellec, H., Stowell, A.F., Johansson, N., 2022. Critiques of the circular economy. J. Ind. Ecol. 26, 421–432. https://doi.org/10.1111/jiec.13187.

Costa, L., Moreau, V., Thurm, B., Yu, W., Clora, F., Baudry, G., Warmuth, H., Hezel, B., Seydewitz, T., Ranković, A., Kelly, G., Kropp, J.P., 2021. The decarbonisation of Europe powered by lifestyle changes. Environ. Res. Lett. 16, 044057. https://doi.org/10.1088/1748-9326/abe890.

Destatis, 2023. Beförderte Personen im Luftverkehr aus Deutschland nach Kontinenten [WWW Document]. Statistisches Bundesamt. URL. https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Transport-Verkehr/Personenverkehr/Tabellen/flugpassagiere.html, 7.18.23.

Destatis, 2022. Flugsommer 2022: Zahl der abfliegenden Fluggäste mehr als verdoppelt. Statistisches Bundesamt [WWW Document]. https://www.destatis.de/DE/Presse/Pressemitteilungen/2022/11/PD22_502_464.html, 7.18.23.

Dobroć, P., Bögel, P., Upham, P., 2023. Narratives of change: strategies for inclusivity in shaping socio-technical future visions. Futures 145, 103076. https://doi.org/10.1016/j.futures.2022.103076.

Ellsworth-Krebs, K., Niero, M., Jack, T., 2023. Feminist LCAs: finding leverage points for wellbeing within planetary boundaries. Sustain. Prod. Consum. 39, 546–555. https://doi.org/10.1016/j.spc.2023.05.035.

Estrada-González, I.E., Taboada-González, P.A., Guerrero-García-Rojas, H., Márquez-Benavides, L., 2020. Decreasing the environmental impact in an egg-producing farm through the application of LCA and lean tools. Appl. Sci. 10, 1352. https://doi.org/10.3390/app10041352.

European Commission, 2010. International Reference Life Cycle Data System (ILCD) Handbook - General Guide for Life Cycle Assessment - Detailed Guidance. Publictions Office of the European Union, Luxembourg.

Font Vivanco, D., Freire-González, J., Galvin, R., Santarius, T., Walnum, H.J., Makov, T., Sala, S., 2022. Rebound effect and sustainability science: a review. J. Ind. Ecol. 26, 1543–1563. https://doi.org/10.1111/jiec.13295.

Font Vivanco, D., Sala, S., McDowall, W., 2018. Roadmap to rebound: how to address rebound effects from resource efficiency policy. Sustainability 10, 2009. https://doi.org/10.3390/su10062009.

Frantzeskaki, N., van Steenbergen, F., Stedman, R.C., 2018. Sense of place and experimentation in urban sustainability transitions: the Resilience Lab in Carnisse, Rotterdam, The Netherlands. Sustain. Sci. 13, 1045–1059. https://doi.org/10.1007/s11625-018-0562-5.

Galvin, R., Gubernat, A., 2016. The rebound effect and Schatzki's social theory: reassessing the socio-materiality of energy consumption via a German case study. Energy Res. Social Sci. 22, 183–193. https://doi.org/10.1016/j.erss.2016.08.024.

Geels, F.W., McMeekin, A., Mylan, J., Southerton, D., 2015. A critical appraisal of Sustainable Consumption and Production research: the reformist, revolutionary and reconfiguration positions. Global Environ. Change 34, 1–12. https://doi.org/10.1016/j.gloenvcha.2015.04.013.

Giddens, A., 1979. Central problems in social theory: action, structure and contradiction in social analysis, Nachdr. Contemporary Social Theory. Macmillan, Basingstoke.

Giddens, A., 1984. The constitution of society. Outline of the Theory of Structuration. University of California Press, Berkeley.

Gnielka, A.E., Menzel, C., 2021. The impact of the consumer's decision on the life cycle assessment of organic pasta. SN Appl. Sci. 3, 839. https://doi.org/10.1007/s42452-021-04822-y.

Greiff, K., Teubler, J., Baedeker, C., Liedtke, C., Rohn, H., 2017. Material and carbon footprint of household activities. In: Keyson, D.V. (Ed.), Living Labs : Design and Assessment of Sustainable Living. Springer, Cham, pp. 259–275.

Grin, J., Rotmans, J., Schot, J.W., 2010. Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change, Routledge Studies in Sustainability Transitions. Routledge, New York.

Guillaume, A., Hubatová-Vacková, A., Kočí, V., 2022. Environmental impacts of egg production from a life cycle perspective. Agriculture 12, 355. https://doi.org/10.3390/agriculture12030355.

Hui, A., Schatzki, T., Shove, E., 2016. The Nexus of Practices: Connections, Constellations, Practitioners. Taylor & Francis.

IPCC, 2018. Global Warming of 1.5°C - an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways. In: The Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. Intergovernmental Panel on Climate Change. Incheon.

Jaeger-Erben, M., Jensen, C., Hofmann, F., Zwiers, J., 2021. There is no sustainable circular economy without a circular society. Resour. Conserv. Recycl. 168, 105476. https://doi.org/10.1016/j.resconrec.2021.105476.

Klitkou, A., Bolwig, S., Huber, A., Ingeborgrud, L., Plucíński, P., Rohracher, H., Schartinger, D., Thiene, M., Żuk, P., 2022. The interconnected dynamics of social practices and their implications for transformative change: a review. Sustain. Prod. Consum. 31, 603–614. https://doi.org/10.1016/j.spc.2022.03.027.

Krog Juvik, A., Halkier, B., 2024. Pathways to more resource-intensive consumption through convenient bundles and complexes of food, mobility and housing practices. Consumption Soc. 3, 2–20. https://doi.org/10.1332/27528499Y2023D000000002.

Lage, J., 2022. Sufficiency and transformation–A semi-systematic literature review of notions of social change in different concepts of sufficiency. Front. Sustain. 3, 954660. https://doi.org/10.3389/frsus.2022.954660.

Lawo, D., Engelbutzeder, P., Esau, M., Stevens, G., 2020. Networks of practices: exploring design opportunities for interconnected practices. https://doi.org/10.18420/ECSCW2020_EP03.

Lee, D.S., Fahey, D.W., Skowron, A., Allen, M.R., Burkhardt, U., Chen, Q., Doherty, S.J., Freeman, S., Forster, P.M., Fuglestvedt, J., Gettelman, A., De León, R.R., Lim, L.L., Lund, M.T., Millar, R.J., Owen, B., Penner, J.E., Pitari, G., Prather, M.J., Sausen, R., Wilcox, L.J., 2021. The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. Atmos. Environ. 244, 117834. https://doi.org/10.1016/j.atmosenv.2020.117834.

Lettenmeier, M., 2018. A sustainable level of material footprint. Benchmark for Designing One-Planet Lifestyles. School of Art and Design, Aalto.

Lombardi, A., Cembalo, L., 2022. Consumption Corridors as a new paradigm of sustainability. Resour. Conserv. Recycl. 184, 106423. https://doi.org/10.1016/j.resconrec.2022.106423.

Loorbach, D., 2020. Transformative innovation and translocal diffusion. Environ. Innov. Soc. Transit. 10.

Loorbach, D., 2010. Transition management for sustainable development: a prescriptive, complexity-based governance framework. Governance 23, 161–183. https://doi.org/10.1111/j.1468-0491.2009.01471.x.

Luederitz, C., Abson, D.J., Audet, R., Lang, D.J., 2017. Many pathways toward sustainability: not conflict but co-learning between transition narratives. Sustain. Sci. 12, 393–407. https://doi.org/10.1007/s11625-016-0414-0.

Markard, J., Raven, R., Truffer, B., 2012. Sustainability transitions: an emerging field of research and its prospects. Res. Pol. 41, 955–967. https://doi.org/10.1016/j.respol.2012.02.013.

Marx, K., 1852. The Eighteenth Brumaire of Louis Napoleon. New York.

Mayring, P., 2014. Qualitative Content Analysis: Theoretical Foundation, Basic Procedures and Software Solution. Klagenfurt.

Morseletto, P., 2020. Targets for a circular economy. Resour. Conserv. Recycl. 153, 104553. https://doi.org/10.1016/j.resconrec.2019.104553.

Mylan, J., Southerton, D., 2018. The social ordering of an everyday practice: the case of laundry. Sociology 52, 1134–1151. https://doi.org/10.1177/0038038517722932.

Nicolini, D., 2010. Zooming in and out: studying practices by switching theoretical lenses and trailing connections. Organ. Stud. 30, 1391–1418. https://doi.org/10.1177/0170840609349875.

Niero, M., 2023. Implementation of the European Union's packaging and packaging waste regulation: a decision support framework combining quantitative environmental sustainability assessment methods and socio-technical approaches. Cleaner Waste Sys. 6, 100112. https://doi.org/10.1016/j.clwas.2023.100112.

Niero, M., Jensen, C.L., Fratini, C.F., Dorland, J., Jørgensen, M.S., Georg, S., 2021. Is life cycle assessment enough to address unintended side effects from Circular Economy initiatives? J. Ind. Ecol. 25, 1111–1120. https://doi.org/10.1111/jiec.13134.

Nobis, C., Kuhnimhof, T., 2018. Mobilität in deutschland - MiD ergebnisbericht (No. FE-nr. 70.904/15). infas, DLR, IVT and infas 360. Bonn, Berlin.

OECD, 2023. OECD Environmental Performance Reviews: Germany 2023, OECD Environmental Performance Reviews. OECD. https://doi.org/10.1787/f26da7da-en.

Orlich, M.J., Jaceldo-Siegl, K., Sabaté, J., Fan, J., Singh, P.N., Fraser, G.E., 2014. Patterns of food consumption among vegetarians and non-vegetarians. Br. J. Nutr. 112, 1644–1653. https://doi.org/10.1017/S000711451400261X.

Pohl, J., Hilty, L.M., Finkbeiner, M., 2019a. How LCA contributes to the environmental assessment of higher order effects of ICT application: a review of different approaches. J. Clean. Prod. 219, 698–712. https://doi.org/10.1016/j.jclepro.2019.02.018.

Pohl, J., Suski, P., Haucke, F., Piontek, F.M., Jäger, M., 2019b. Beyond production—the relevance of user decision and behaviour in LCA. In: Teuteberg, F., Hempel, M., Schebek, L. (Eds.), Progress in Life Cycle Assessment 2018. Springer International Publishing, Cham, pp. 3–19. https://doi.org/10.1007/978-3-030-12266-9_1.

Poore, J., Nemecek, T., 2018. Reducing food's environmental impacts through producers and consumers. Science 360, 987–992. https://doi.org/10.1126/science.aaq0216.

Potting, J., Hekkert, M., Worrell, E., Hanemaaijer, A., 2017. Circular Economy: Measuring Innovation in the Product Chain (Policy Report). The Hague.

Reckwitz, A., 2002. Toward a theory of social practices: a development in culturalist theorizing. Eur. J. Soc. Theor 5, 243–263. https://doi.org/10.1177/13684310222225432.

Reike, D., Vermeulen, W.J.V., Witjes, S., 2018. The circular economy: new or refurbished as CE 3.0? — Exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options. Resour. Conserv. Recycl. 135, 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027.

Reuter, M.A., van Schaik, A., Gutzmer, J., Bartie, N., Abadías-Llamas, A., 2019. Challenges of the circular economy: a material, metallurgical, and product design perspective. Annu. Rev. Mater. Res. 49, 253–274. https://doi.org/10.1146/annurev-matsci-070218-010057.

Riedy, C., Waddock, S., 2022. Imagining transformation: change agent narratives of sustainable futures. Futures 142, 103010. https://doi.org/10.1016/j.futures.2022.103010.

Røpke, I., 2009. Theories of practice — new inspiration for ecological economic studies on consumption. Ecol. Econ. 68, 2490–2497. https://doi.org/10.1016/j.ecolecon.2009.05.015.

Røpke, I., Christensen, T.H., 2012. Energy impacts of ICT – insights from an everyday life perspective. Telematics Inf. 29, 348–361. https://doi.org/10.1016/j.tele.2012.02.001.

Rütt, J., Hennes, L., Teubler, J., Braun, B., 2022. How compatible are Western European dietary patterns to climate targets? : accounting for uncertainty of life cycle assessments by applying a probabilistic approach. https://doi.org/10.3390/su142114449.

Sala, S., Benini, L., Beylot, A., Castellani, V., Cerutti, A., Crenna, E., Diaconu, E., Sanyé-Mengual, E., Secchi, M., Sinkko, T., Pant, R., 2019. Consumption and Consumer Footprint: Methodology and Results (Technical Report). Joint Research Center (JRC), Ispra.

Samson, C., 2024. Understanding interrelated practices and their climate-related consequences: exploring food, mobiliy and housing in everyday life. Consumption Soc. https://doi.org/10.1332/27528499Y2024D000000010.

Scheer, J., Wolf, I., Middendorf, S., Pöpsel, L., Schmitz, L., 2021. Mobilitätsbefragung 2020 Stadt Wuppertal. Wuppertal.

Scheurenbrand, K., Schatzki, T., Parsons, E., Patterson, A., 2023. How do unsustainable practices remain dominant? A practice theory reinterpretation of gramsci. Sociology 00380385231178643. https://doi.org/10.1177/00380385231178643.

Shove, E., 2010. Beyond the ABC: climate change policy and theories of social change. Environ. Plann. 42, 1273–1285. https://doi.org/10.1068/a42282.

Shove, E., Pantzar, M., Watson, M., 2012. The Dynamics of Social Practice: Everyday Life and How it Changes. SAGE, Los Angeles.

Sonnberger, M., Gross, M., 2018. Rebound effects in practice: an invitation to consider rebound from a practice theory perspective. Ecol. Econ. 154, 14–21. https://doi.org/10.1016/j.ecolecon.2018.07.013.

Speck, M., Hasselkuss, M., 2015. Sufficiency in social practice: searching potentials for sufficient behavior in a consumerist culture. Sustain. Sci. Pract. Pol. 11, 14–32. https://doi.org/10.1080/15487733.2015.11908143.

Spurling, N.J., McMeekin, A., Southerton, D., Shove, E.A., Welch, D., 2013. Interventions in practice: reframing policy approaches to consumer behaviour. Sustainable Practices Research Group.

Statista, 2023a. Per capita consumption of meat in Germany from 1991 to 2022 [WWW Document]. Statista. URL. https://www.statista.com/statistics/525324/meat-per-capita-consumption-germany/, 7.31.23).

Statista, 2023b. Anzahl der Urlaubsreisenden in Deutschland bis 2022 [WWW Document]. Statista. URL https://de.statista.com/statistik/daten/studie/151940/umfrage/anzahl-der-urlaubsreisenden-in-deutschland-seit-2005/. , 7.18.23.

Stedman, R.C., 2003. Is it really just a social construction?: the contribution of the physical environment to sense of place. Soc. Nat. Resour. 16, 671–685. https://doi.org/10.1080/08941920309189.

Stedman, R.C., 2002. Toward a social psychology of place: predicting behavior from place-based cognitions, attitude, and identity. Environ. Behav. 34, 561–581. https://doi.org/10.1177/0013916502034005001.

Stedman, R.C., Ingalls, M., 2014. Topophilia, biophilia and greening in the red zone. In: Tidball, K.G., Krasny, M.E. (Eds.), Greening in the Red Zone. Springer, Netherlands, Dordrecht, pp. 129–144. https://doi.org/10.1007/978-90-481-9947-1_10.

Steffen, W., Richardson, K., Rockstrom, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B., Sorlin, S., 2015. Planetary boundaries: guiding human development on a changing planet. Science 347, 1259855. https://doi.org/10.1126/science.1259855, 1259855.

Stewart, W.P., Liebert, D., Larkin, K.W., 2004. Community identities as visions for landscape change. Landsc. Urban Plann. 69, 315–334. https://doi.org/10.1016/j.landurbplan.2003.07.005.

Suski, P., Palzkill, A., Speck, M., 2023. Sufficiency in social practices: an underestimated potential for the transformation to a circular economy. Front. Sustain. 3, 1008165. https://doi.org/10.3389/frsus.2022.1008165.

Suski, P., Speck, M., Liedtke, C., 2021. Promoting sustainable consumption with LCA – a social practice based perspective. J. Clean. Prod. 283, 125234. https://doi.org/10.1016/j.jclepro.2020.125234.

UNEP, 2020. Guidelines for Social Life Cycle Assessment of Products and Organizations 2020. In: Benoit Norris, C., Traverso, M., Neugebauer, S., Ekener, E., Schaubroeck, T., Russo Garrido, S., Berger, M., Valdivia, S., Lehmann, A., Finkbeiner, M., Arcese, G. (Eds.). United Nations Environment Programme (UNEP).

Upham, P., Gathen, L., 2021. Actors in transitions: narratives of roles and change in the German e-mobility transition. Environ. Innov. Soc. Transit. 40, 450–460. https://doi.org/10.1016/j.eist.2021.09.009.

Walker, A.M., Simboli, A., Vermeulen, W.J.V., Raggi, A., 2023. Adopting a socio-material perspective on life cycle assessment: environmental impacts of circular tableware systems in Italy's bioplastics context. Sustain. Dev. sd 2839. https://doi.org/10.1002/sd.2839.

Warde, A., 2017. Consumption. Palgrave Macmillan UK, London. https://doi.org/10.1057/978-1-137-55682-0.

Warde, A., 2005. Consumption and theories of practice. J. Consum. Cult. 5, 131–153. https://doi.org/10.1177/1469540505053090.

Welch, D., Keller, M., Mandich, G., 2017. Imagined futures of everyday life in the circular economy. interactions 24, 46–51. https://doi.org/10.1145/3047415.

Williams, R., 1976. Keywords: a Vocabulary of Culture and Society. Oxford University Press, New York.

Wittmayer, J.M., Backhaus, J., Avelino, F., Pel, B., Strasser, T., Kunze, I., Zuijderwijk, L., 2019. Narratives of change: how social innovation initiatives construct societal transformation. Futures 112, 102433. https://doi.org/10.1016/j.futures.2019.06.005.

Yang, Y., Heijungs, R., 2018. On the use of different models for consequential life cycle assessment. Int. J. Life Cycle Assess. 23, 751–758. https://doi.org/10.1007/s11367-017-1337-4.

Zwiers, J., Jaeger-Erben, M., Hofmann, F., 2020. Circular literacy. A knowledge-based approach to the circular economy. Cult. Organ. 26, 121–141. https://doi.org/10.1080/14759551.2019.1709065.

5 Synthesis

In a discussion that overarches the preceding publications, central aspects of this work that are relevant to the research objective are being summarized and synthesized. It was shown, that life cycle assessments can be brought to a next level of comprehensiveness by adopting a social practice theoretical perspective and putting a strong emphasis on the nexus of social practices. Including the social embeddedness of research objectives by zooming out of social practices allows to follow change through the nexus of social practices, and hence, understand and assess transformative change. This broadens the spectrum of applications of LCA and can increase the value of the LCA results, as shown for the case of urban sharing. This confirms the hypothesis of this dissertation. In addition to such methodological considerations, a synthesis of the empirical findings on urban sharing and what they mean for the discourse on the circular economy will be provided, which in turn further underlines the relevance of the methodological development. Furthermore, the implications of the methodological and empirical finding for future research will be discussed.

5.1 Methodological considerations

Throughout this dissertation and most prominently in chapter 2, it was shown that LCA has developed quite well in the recent decade in order to make the method available for questions of sustainable consumption and everyday life, introducing LCA based household analysis and higher order effects (including rebound effects) in LCA. There are also already several LCA studies on the sharing economy available that test different ways to address some sorts of higher order effects. This embarks the question, if an LCA of urban sharing could have been done more traditionally and why the methodological detours through social theories, interviews, zooming in and out were taken.

RQ1 aimed at ways to make use of social practice theoretical thinking in LCA. What has been discussed, developed and tested throughout this dissertation in this regard is basically the complete opposite to what was done before in LCA, as in the beginning it became clear that the strict supply chain focus, as the basis for comprehensive assessments in LCA must be abandoned. Instead of starting with a supply chain analysis and later add surrounding (social / economic) changes by various methods, these surrounding changes themselves were made the centre of analysis. This allowed to think about social change, without being tied to life cycle stages and material flow logics. The analysis of a nexus of social practices by zooming in and out was made the starting point of working on environmental impact assessments. To answer RQ1: Theories of social practice can be used for comprehensive LCA, by using LCA to environmentally assess the material base of a nexus of social practices.

This shift in focus from supply chains to social practice nexuses does not necessarily mean that LCA as such is abandoned. Instead, it is rather a reinterpretation of LCA as multi-method approach to assess environmental impacts, where supply chain analysis is only part of the life cycle inventory analysis, which is one step of many. To made clear why this focus on social practices might be beneficial, we should go back to Zamagni et al. (2012) one more time, who concluded in their systemic literature review on the state of (consequential) LCA, that generally it is neglected to reflect on what LCA is actually for.

"As far as the *what for* is concerned, the analysis highlights that this aspect is not well addressed at the methodological or practical level, despite its relevance. The correct formulation of a question is central in every evaluation, but its importance continues to be neglected. [..] How to better link questions and models is an important field of research, not only for CLCA [consequential LCA], and it requires the development of practical guidelines on how to frame questions, to identify what the problem to be tackled is exactly, what the derived questions are, what the technological options are what the scale of the expected changes is, what the time frame of the questions is, if a ceteris paribus assumption may hold, if the system analysed is replacing another system at a small scale, or if the technology used in the new system is expected to extend to many more applications on a larger scale." (Zamagni et al., 2012: p. 916).

In this dissertation, theories of social practice were introduced to tackle this issue of underspecified and underanalysed goals and scope in LCA. With the analysis of a nexus of social practices and hence, the embeddedness of social practices, the scope of an LCA is not simply defined in the beginning, but is identified by applying empirical methods based on theories and practical considerations, or in short: by doing research. In the analysis of current methodological approaches to address complex systems that are consumption relevant, it was shown that until today, many studies miss to provide a thorough discussion on what the study is for, how it could be used to promote change and what would be the overall outcome of this change, which leads to the conclusion that there are methodological shortcomings. Conducting an LCA of urban sharing could have been done without fundamentally questioning methodological traditions, but such studies would most likely more or less miss the point of urban sharing due to a wrong framing of the question and hence come to very different conclusions. Only by analysing what urban sharing actually means for the production and consumption system, relevant supply chains that need to be quantified could be identified.

The shortcomings in the framing of problems, especially in the field of consumption, is often based on a lack of awareness of the social (or the ontological convictions), which then leads to methodological developments, like including time use or income elasticities in LCA, without analysing whether those are appropriate approaches for given research objects. By

providing an explicit account of the ontological standpoint, this dissertation adds a new layer of reflection and transparency, which enables more interdisciplinarity, as shown in the empirical studies of publication B and C. Fundamentally, when LCA shall be used in order to inform stakeholders on why and how to change our consumption system (which is a corner stone of the circular economy), a proper understanding of consumption and how it is embedded in our society is necessary.

This shows that the fundamental problem with LCA (or any other impact assessment method for that matter) is, that when it is understood as strict quantitative method, they can be correct, in the sense that there are no errors in the calculations or methods applied, while still be bad, irrelevant or misleading and that it is hard to identify such cases, especially for stakeholders outside of academia.

By including comprehensive discussions on the essence of social change in front of any material flow analysis, it could be ensured that there is a profound theoretical and empirical base for identifying the system boundaries and unit of analysis of urban sharing, which no other approach could do. This also shows that an additional problem of framing questions in LCA, which was addressed in this dissertation, often comes down to an implicit comprehension of sustainability as such. LCA was mainly developed in the 1990s (while earliest developments are dating back to the late 1960s), were environmentalism often meant product optimisation and incremental technological change (new light bulbs, energy efficient appliances etc.), which was further reinforced by the introduction of the triple bottom line (people, planet, profit) way of thinking (Elkington, 1994). Traditional LCA is good at providing help here. However, there is a strong criticism regarding the environmental potential of technological optimisation and the triple bottom line way of thinking, as it works towards keeping the status quo and persisting transformational change, by trusting that 'green capitalists' (Elkington and Burke, 1987) and informed lifestyle changes of citizens will achieve sustainable development (Hopwood et al., 2005). These proponents of weak sustainability rarely address the general consumer culture or questions of governance and instead rely on environmental impact assessment methods and eco-management tools (Hopwood et al., 2005). In contrast, sustainable development is being understood by many researchers outside of LCA and sustainable management as a social-ecological transformation that questions more fundamentally power, agency and economic distribution, with diverging ideas of how exactly this plays out (Brand and Wissen, 2017). Even Elkington himself recalled his invention of the triple bottom line, as he observed its broad misconception as a simple management tool, instead of a guideline to deeply rethink capitalism's structure (Elkington, 2018). By intro-

ducing social practice theories to LCA and looking at nexuses of social practices, this dissertation provides a new way for LCA practitioners to look at sustainable development, by adopting the idea of social-ecological transformation.

This differentiation in comprehending sustainable development is also reflected in the discussed differences between traditional circular economy literature and the newer discourse on circular society. It is also the reason for choosing to analyse and environmentally assess urban sharing over sharing economy activities. This again shows, how early in the process of LCA decisions for the goal and scope phase can be made, out of implicit understandings of the world and how it changes, or ought to change.

What does this have to do with methodology? In order to frame problems of unsustainable consumption, theories of social practices were introduced in publication A. Doing a study social practice informed shapes questions and somewhat define the unit of analysis which then implies the use of certain methods depending on the specific case. In the case of sharing, it means that sharing as a social phenomenon, as a social practice in itself is being analysed and not a good that is being shared. The understanding of sustainable development as a transformative process implies that environmental impact assessments need to be aware of the societal systems their unit of analysis is embedded in, or the assessments cannot be used effectively. Having to *understand* something is a different methodological premise to *describing* material flows, which is traditionally the goal of LCA. In a very basic methodological conclusion, it could be shown that doing a social practice based LCA relies on a mixed-method approach, including qualitative and quantitative methods. Qualitative methods, like semi-structured interviews, for data collection and qualitative content analysis for the interpretation of collected data, are necessary at least for identification of system boundaries and stakeholders. Quantitative methods, like surveys, are necessary to quantify materials used in social practices. This is then followed by further quantitative material flow analysis and impact assessments as part of the LCA. As shown throughout publication B and C, qualitative analysis functions as the very basis of the environmental impact assessment and is not an explorative add-on, as often shown in mixed-method approaches in sustainability assessments. Depending on the empirical case and specific research objectives, methods can change and add up, e.g. including observations and narrative analysis, but a general mixed method approach must remain.

By introducing nexuses of social practices as system boundaries for LCA, a problem was introduced to quantify environmental potentials. A potential is the difference between two states, which means that it is not enough to just calculate the environmental impact of sharing, as it needs to be set in relation to something. The regular way of assessing the environ-

mental potential of something, like sharing activities, is to directly compare it to its counterparts (carsharing vs. car owning). Comparisons are based on shared functional units and system boundaries to make them (seem) fair. This becomes problematic for multifunctional products (there is a debate that most end consumer products are multifunctional and only the strict technological perception of them makes it easy to compare, but that aside). As discussed throughout this dissertation, this also leads to arbitrary definitions of system boundaries just to make alternatives fit (this includes rebound effects, as they are added to make fair comparisons to the status quo). This methodology gets absurd when different consumer cultures (e.g. materialist vs. sharing) shall be compared. What are shared functions when the very idea is, that the function of a sharing society is different to the status quo? In regard to system boundaries, we face the problem, that the system boundary of urban sharing is identified by the practice nexus, but whatever would be identified as the counterpart of sharing practices, would exist in a different nexus and hence, lead to different system boundaries.

The presented and tested solution is a comparison with a counterfactual baseline. The environmental potential of urban sharing is compared to the case that there would be no urban sharing. Here, the actual function of urban sharing as such is not important, as there is no comparison at this level. Instead, the identified social practices within the practice nexus are being compared to their status quo version separately. For example, when travelling changes as an aspect of urban sharing, we can compare changing travel practices with the status quo of travelling. As shown in publication C, this process can be repeated for every affected social practice in the nexus and the environmental potentials can be added up. This counterfactual approach can lead to well known results on product-level assessments, for example LCA practitioners might say “if they would not have bought the car, they would use the train”, a fairly common type of comparison based on shared functions. However, not having a car can also lead to staying at home, a comparison that is forbidden in traditional LCA as there is no shared functional unit. Not as a primary goal, but as a consequence of social practice thinking, this dissertation introduced a radical paradigm shift for LCA, by questioning the very idea of fair comparisons by shared functional units and replacing it by counterfactual baselines. Additional research should be conducted in order to specifically analyse this procedure and to identify strengths and limitations.

Identifying the nexus of social practices in itself places certain demands on the definition of system boundaries for the environmental assessment. In traditional, product-based LCA, the system boundaries are usually relatively easy to determine, as there are experts who already know the supply chains quite well and those can be interviewed. However, this is different when it comes to the nexus of social practices, as in most cases there is no prior knowledge

of what this nexus looks like. Therefore, instead of short expert interviews, extensive qualitative research from the field of social sciences is needed to determine the system boundaries. This shows that working on the goal and scope phase in a social practice based LCA can and should be taken more seriously and be planned strategically by choosing appropriate methods. Getting to understand something that is about to be assessed is research in its own right. Considering the vast number of results on urban sharing gathered throughout the empirical phase of this dissertation, it can be concluded, that investing more time and effort in the goal and scope phase might actually save research time in the long run, as it skips various semi-redundant LCAs of small proposed aspects of sharing and the integration of multiple research strains from various disciplines.

The extensive analysis of sharing before any calculations were done, resulted in publication B that only addresses aspects of the goal and scope phase (even though this LCA language was not used in the article itself, as it did not contain an LCA as such). As the results provide system boundaries that could not have been predicted or expected to be found by any other LCA method that aims to identify higher order effects (e.g. statistical analysis of income or time elasticity), it could be shown, that the extra effort in this social practice based LCA methodology is crucial in getting comprehensive and relevant results. Relevance here refers to a proper representation of what there actually is. It needs to be stressed again that not the sharing of a tool, a book or a car was environmentally assessed, but an LCA of urban sharing *as such* was conducted. While it might seem as a minor lingual difference between, the empirical analyses in this dissertation proved the big difference. Do I, as a researcher, follow the good in an analysis or do I follow the social practice? Both options require different methods to be applied, both indicate a different understanding of sustainable development, both address different stakeholders to some extent, both lead to different results and conclusions.

Furthermore, it was shown, that the methodological framework of zooming in and out of social practices by switching lenses, proposed by Nicolini (2010), is also useful in the context of LCA as it provides a comprehensive approach to analyse specific social phenomena and its impacts on society. Zooming in (here: on urban sharing) is a necessary step to identify relevant stakeholders and their roles, to specify the decision-making context in which the LCA is being applied and to generally understand the phenomenon under investigation (i.e. the goal). Zooming out, as already discussed, then helps to identify system boundaries and everything that is inside of it, here referred to as the nexus of a social practices (i.e. the scope). Generally, there is a wide variety of methods available to do such analyses (Nicolini, 2010 provides a long, but non-exhaustive list). In this dissertation, however, only a limited number of methods was available due to corona lockdown restrictions. A combination of semi-structured online interviews, group workshops (also online) and a survey was used to

collect data for scoping. As this is a very time-consuming endeavour compared to normal goal and scope phases in LCA, the necessary effort for data collection was thoughtfully planned to minimize time demand. Data collection efficiency included a short survey that was integrated in the online workshop, a workshop which itself consisted of several parts, one to zoom in, one to zoom out and semi-structured interviews that focused on some of the environmentally most relevant fields of consumption (travelling, mobility and nutrition). Additionally, time was saved by planning an integration of data collection for the goal and scope phase and for the inventory analysis, by using the interviews to fill gaps from a survey, and placing the survey for the inventory analysis at the end of the workshop for the goal and scope phase. Future research could address the effective application of data collection methods more specifically in order to streamline this mixed-method LCA approach.

Overall, this discussion shows that there is too much focus on calculations in LCA. From the four phases of an LCA, according to ISO 14040, only two are directly about calculations (inventory analysis and impact assessment), while the other two (goal and scope definition and interpretation) provide qualitative framings and an understanding for such assessments. In this dissertation it is shown, that insightful LCA is possible when adjusting the methodology to focus less on the quantitative part and more on answering the 'what for'. Here it could be argued, that in analogy to Elkington's reflection on his own work (2018), also LCA should not be reduced to a mere management tool, which is too often the case, but that this life cycle perspective should emphasise more generally critical thinking on diverse types of dependencies along material flows and supply chains, that need to be comprehensively analysed.

These methodological reflections are also displayed in the structure of this dissertation. Publication A lays out a methodology that is based on the embeddedness of social change that needs to be recognised in holistic environmental assessments. Publication B provides an empirical case that qualitatively provides answers for the goal and scope phase as well as results that can be used for interpretations. Only publication C includes an actual calculation of an LCA on urban sharing that tests the theoretical framework from the publication A and uses the problem definition of publication B. However, even the third article includes further qualitative analysis in order to understand how the quantitative results come about, and what cone be done with it. The analysis of narratives of place and change proved to be an addition to LCA that is worthwhile for the case of urban sharing.

It must be recognized, that a social practice based LCA is interdisciplinary in nature due to its complex methodological approach and that this interdisciplinarity can be problematic to handle. Usually, there are not many researchers familiar with quantitative assessments of material flows along supply chains and qualitative social sciences on consumption. This multifaceted methodology turned out to be conceptually and practically the hardest hurdle in

the course of this dissertation. However, LCA in itself was always situated somewhere between several disciplines, including engineering, chemistry, economics, geology, architecture, ecotrophology and ecology, to name just a few. It actually is a method and a field of research, that somehow exists beyond traditional scientific disciplines. So, in analogy to Brandão and Weidema (2012), who, as LCA researchers, reached out into the literature of economics, it is reasonable to ask 'what can LCA learn from social sciences?', for which this dissertation serves as an answer, even though not an exhaustive one.

5.2 Empirical considerations

Every methodological development is only as good as its practical utility in an empirical study. By reflecting on the multifaceted results on urban sharing provided in this dissertation, its embeddedness in daily life and the corresponding environmental potential, a more comprehensive discussion on the value and potential of social practice based LCA shall synthesise the findings.

First of, and as more extensively described in publication B, it could be learnt that what is being assessed, urban sharing in the Arrenberg initiative, can be described with sufficiency, while more traditional sharing economy activities tend to be more about efficiency and effectivity. The sharing economy has access as a central feature (Acquier et al., 2017) and optimised access to material goods can be a problematic, as it often leads to an increased demand of such material goods, a centuries old trap of efficiency that leads to further growth (Jevons, 1865). The analysis of urban sharing shows that not access to goods, but participation in a community that aims at improving local life and sustainability is central to urban sharing practices. Sharing here refers to shared infrastructure, public and private space, narratives of place and change, sharing as collaboration and participation. Several identified urban sharing activities are not even related to any economic benefits (e.g. urban gardening, open restaurant day), which shows that economic rebound effects might only play a minor role, if any, which is different to many cases of the sharing economy.

In an analysis of the nexus of urban sharing practices in publication B and C, RQ2 was answered by showing how it is connected to social practices, such as shopping groceries, urban mobility and travelling by shared meanings of enough and environmentalism. In order to better understand how it came to be, that those social practices form a nexus, available data was further analysed in publication C. Here it could be revealed that shared narratives of place and change serve as connectors in the nexus. Sharing here gets an additional layer, as shared narratives are an important ingredient for social change, whether those shared narratives are related to sharing as such or not. However, both aspects of sharing are related to each other in the sense, that both rely on an active local community.

The qualitative studies were crucial for the environmental assessment. The first analysis was necessary to define the system boundaries, as they are the nexus of urban sharing practices. The second analysis helped to understand the process of change, which is important in the LCA, when it comes to interpreting the quantitative results, as it is not just relevant if something needs to be supported, but also how and by whom. It was shown, that urban development towards multifunctional neighbourhoods can play a crucial role in supporting sufficient and sustainable urban sharing practices. This can be taken up by local communities and regional parliaments, as well as national and European legislation and funding schemes, like national urban development plans (in Germany the 'Städtebauförderung' of the Federal Ministry for Housing, Urban Development and Building) or the European Regional Development Fund and their regional partners. Those are some rather unusual addresses to support sustainable consumption, which shows the relevance of thoughtful investigation of the phenomenon under investigation.

The analysis of urban sharing further revealed that urban sharing is to some extent radical and conservative at the same time. Radical as the orientation on sufficiency is in contrast to the overall growth paradigm that we are generally confronted with. Conservative, as this does not entail a grander political or economic agenda, but rather reflects the image of a simpler life that can be found in the participants own childhood. Several interviewees referred to the Arrenberg neighbourhood as village-like: people know each other, people help each other, people can fix things and have practical knowledge etc. It shows, that sufficiency does not mean sacrifice, but a reorientation towards resonant relationships, which steers towards a transformation of wealth, as material growth is substituted with experience, affect and self-efficacy.

These findings are relevant for the LCA as they show to political stakeholders, that the shift in consumer culture can be promoted by rather low-threshold interventions, like supporting third places in neighbourhoods, financially, administratively or otherwise. This is a very practical example of what it means to abandon individualist approaches to the social that often aim at informing or nudging individuals, while the adoption of nonindividualist thinking here seeks to establish sustainable infrastructures. Additionally, it is shown here, that stakeholders do not need to be afraid in admitting that life has to change in order to stay within planetary boundaries, as it can actually mean that it gets better, not only in a counterfactual way, but compared to the current state of life. Especially the discourse on the circular economy is still technology focused, while the example of urban sharing shows, what it can mean, to stick to the inner circle and try to reduce the material base by refuse, rethink and reduce strategies in daily life.

It must be further stressed, that this dissertation shows that the dominant problem-solving policy paradigm, which is also prevalent in LCA studies, tends to overlook transformational potential. As it is widely understood that mobility, traveling and nutrition are environmentally relevant fields of consumption, LCAs and other forms of analysis and policy interventions, aim directly and separately at those fields of consumption (e.g. by eco-labelling or taxation). As shown with the case of urban sharing, there are measures that address unsustainable consumption at a more general and less immediate level. This dissertation was only able to identify the high environmental potential by conceptualising comprehensive environmental assessment differently.

Based on the methodological development and thorough description of urban sharing, an environmental assessment was conducted in order to answer RQ3, the environmental potential of urban sharing. The results, presented in publication C, show that the cultural shift of sharing, which transcends through daily mobility, nutrition and travelling practices, inherits a high environmental potential (reduction of ca. 1,5 t CO2-eq. per person and year). This proofs the importance of properly zooming out of sharing to grasp the environmental potential of its transformative change. Comprehensive assessments need such broad perspectives and they need to be based on primary data as much as possible. Other known approaches to environmentally assess sufficiency or other transformative measures, such as time or income elasticities are not be able to identify such specific societal processes. The results are insofar even more interesting as the sharing of material goods itself was not part of the calculations, but only what is described by other LCA practitioners as higher order effects and what is called in this dissertation the nexus of urban sharing.

The change in the diet towards a lower intake of animal products, has the highest environmental impact. This cannot be solely explained by sharing as such, but is influenced by the fact, that food and nutrition is one topical pillar of the Arrenberg initiative, which includes for example food sharing, urban gardening, an open restaurant day (sharing of private kitchens) and sharing childhood related food. This shows that it is not just important to include food related social practices in transformation agendas, but more generally, that there are synergies in multi-facetted approaches to urban transformation that need to be considered politically, but also methodologically in research activities. The results lead to the hypothesis that mono-thematic sharing, e.g. a separated food sharing initiative or cloths swapping event is not or barely affecting the diet, daily mobility or travelling.

Despite the information that were used for the LCA, data, especially from the interviews, also showed that what was being environmentally assessed is not a rigid state of culture that established after a finished transformation. There is no fixed state of society A that can be compared to a fixed state B. Instead, several interviewees pointed out, that life is within a

process of change, while we were talking. This might sound banal on this very basal level, however, it shows that any quantitative assessment of environmental potential of transformative change is dependent on the specific point in time, when data collection occurs. While this makes the actual numbers of the calculations arbitrary to some extent, it can be argued that the very precise calculations are not the point in the first place when dealing with transformations. This dissertation showed that a change in nutrition is a highly relevant factor in the environmental assessment of urban sharing and that it is being followed by travelling and daily mobility. Overall, it is shown that the environmental potential is high enough to be taken seriously for the transformation of our consumption system by urban sharing initiatives. However, the results should only carefully be used in for example quantitative upscaling scenarios or national climate mitigation strategies, as the environmental effect of broadly established urban sharing practices remains unclear. This is not a shortcoming of this of this dissertation, but a feature of society as such, as cultural trends do not occur linearly and plannable. This shows that LCA in transformative processes is not necessarily about highly sophisticated mathematics, as the question never was choosing A or B. Instead, highly sophisticated qualitative analysis of the social phenomenon in combination with quantitative data lead to the important results. Some summarized conclusions from the empirical analyses shall underline this point:

- Sustainable consumption should not (only) be thought and assessed in separable consumption categories (nutrition, mobility, housing etc.), as social practices within those areas are too intertwined. This needs to be reflected in research agendas and policies.
- The environmental potential of urban sharing lays not in the sharing of goods as such, but in its shift in the consumption culture due to its local embeddedness, meanings of enough, environment and community. Technological upscaling in the form of digital applications would most likely undermine this potential, if not properly utilized as a support for existing local networks. In this sense, urban sharing must be understood as the resonant counter-draft to the silent, anonymous and growth-oriented sharing economy (not saying that the sharing economy is bad per se).
- Researchers, policy makers and other stakeholders for sustainable consumption should be open minded when looking for solutions. Instead of just focusing on social practices that are highly environmental relevant (e.g. eating and driving) in an urge to change them, looking for (emerging) social practices that are environmentally irrelevant might be more interesting. Gardening, walking the dog, volunteering, being creative and many other social practices are time intensive, probably resource-friendly and improving life satisfaction.

- The results show, that in order to raise the environmental potential of urban sharing, an active, socially connected and multifunctional neighbourhood is necessary. This connects the topic of sustainable consumption with urban development. The separation of the city in various functions (dwelling, working, shopping etc.) and the automotive city, which are important urban planning principles since the 1930s, need to be rethought in order to allow for an urban sharing society to develop.

These results clearly show, that the environmental assessment did not simply reveal numbers, but an understanding of urban sharing itself which helps to identify critical stakeholders (anyone involved in urban development, citizen who might participate in or initiate sharing activities when provided necessary infrastructure) and levers to support urban sharing. That urban planning is an important leverage without having it in focus by a hypothesis, but as a result of a research process that aims for reducing environmental impacts, shows that the additional effort implied by the adjusted methodological approach, can be worth it.

The results are, however, not only specific to a point in time (as discussed above), but also to a place. The interviews revealed that taking anything sharing specific from the Arrenberg Initiative to another neighbourhood seems not possible in short term on the individual level. The social practice of urban sharing is still emerging and it cannot be predicted if and how it will manifest, due to e.g. place related narratives and local networks of human actors. This can be problematic, as policies and environmental strategies of various stakeholders are often developed with clear mitigation potentials in mind, for example as part of European policy cycles which demand environmental assessments as part of the better regulation guidelines (European Commission, 2021). How much CO_2-eq. can be saved when a couple of million Euros are spent on urban sharing? Taking the nexus of practices and the unexpected areas this analysis led us to seriously, means that it is not foreseeable what will happen if consumption culture shifts on a larger scale (Augenstein et al., 2020). The connections between sharing, nutrition, mobility and travelling are still about to connect. As said before, urban sharing is also dependent on the paradigm of urban development. This study could however not reveal, what will happen if the paradigm of the functional and automotive city changes towards more multifunctional quarters on a national or international level. This will again affect many social practices within the nexus. In regard to investment into environmental mitigation strategies, whether by local, national or international policy makers or financial or other private institutions, these results show, that there must be room for action, that cannot be fully quantified. However, this dissertation also shows that quantitative environmental assessment can play a role in such fuzzy transformative areas, even though there

are limits to it. It is more about general environmental relevance connected to specific processes in society that can help in steering transformation (as much as this is possible), rather than a definitive answer of an object that can be clearly defined and demarcated.

This questions the role of quantitative (environmental) assessments generally. Quantifiable key performance indicators, that are often used to measure progress, were originally meant to help progress happening. However, way too often the opposite can be observed, as everything that is not quantifiable or does not pay towards the defined indicator is being left out. The tool that shall help to reach a goal, becomes the goal itself. And as they are reductionist in nature, potential for progress is lost. In the field of environmental protection strategies, this is a grave mistake.

In a more general notion, Horkheimer and Adorno (2002 [1987] p. 20) put it this way: 'The reduction of thought to a mathematical apparatus condemns the world to be its own measure. What appears as the triumph of subjectivity, the subjection of all existing things to logical formalism, is bought with the obedient subordination of reason to what is immediately at hand. [..] [M]athematical formalism, whose medium, number, is the most abstract form of the immediate, arrests thought at mere immediacy.'

This dissertation shows that mathematical formalism can be used, while withstanding getting arrested by it, in order to proceed more effectively towards a sustainable circular society.

5.3 Implications for future work

This work underlined once more the importance of interdisciplinarity and critical reflections on methodologies and theories, especially in the very early stages of research projects. Taking grander conceptualisations of circularity seriously, including a transformation of our consumption system as described in the European Commission's Circular Economy Action Plan, implies that we have to form teams that are able to address the various dimensions involved in such plans, like material flow aspects, consumption culture and transformation processes. Depending on the empirical case, further expertise needs to be included, like urban development, mobility or nutrition. This call for interdisciplinarity is as relevant for project funding organisations as it is for researchers themselves, as they must be willing to leave their comfortable position in disciplinary departments. More specifically, this addresses the environmental assessment community, as it could be shown that there is much potential for further development. Besides this dissertation, there is some other recent work, that showed that there is a promising future for LCA practitioners in interdisciplinary settings, especially with social practice theorists (Speck and Hasselkuss, 2015; Niero et al., 2021; Ellsworth-Krebs et al., 2023). Furthermore, research institutes like universities should reflect on implementing measures to allow for better interdisciplinary work in the field of circularity by

the way topic centres, departments or positions for professors are established, developed or newly appointed.

Thematically, it can be concluded that further research should focus more on third places and their role for sustainable and circular consumption and production. As the qualitative results have shown, the environmental potential does not lie in specific things that are being shared, but in places and values that are being shared with the local community. People get involved rather quickly and creatively, when they have places beyond their home and work that provide basic infrastructure (physically, but also organisationally). Such third places can come in various forms, from newly developed urban sharing hubs, to very traditional allotments. There is already literature on such third places, but broad environmental assessments are missing.

On a more general note, it should be concluded from this work, that looking for the good life, rather than areas and social practices with high environmental impacts can reveal new promising mitigation strategies. In this way, we are able to escape narrow, sector specific solutions. Looking at, for example, high impact nutrition issues (e.g. meat and dairy products), we are likely to find some solutions with a lower environmental impact (e.g. plant based protein), but we will most likely do not find anything in regard to urban sharing or third places. Of course, the environmental potential of urban sharing is also due to a shift towards less meat and dairy, but the perspective on problem solving is completely different, as it is not product or sector specific. It sparks the question, what else is out there, that works as a boundary object for broad transformations of our consumption system.

5.4 Circular economy and circular society

In the vast discourse on circular economy conceptualizations and strategies, one can find a repeated reminder that consumption-based strategies show high(-est) environmental potential, while research and actual measures in this domain remain mostly neglected and ill conceptualised. Another aspect of circular economy strategies that is often proposed, but also being criticized for being left out practically, is the idea of transformation of production and consumption systems instead of pursuing incremental change. Both aspects were being addressed in this dissertation and the results on urban sharing show, that much potential that is critical to remain within planetary boundaries is lost due to sidelining consumption-based strategies. The analysis and assessment of urban sharing shows, that not small incremental, but transformative change is necessary to drastically decrease the demand of natural resource and hence, environmental impacts. Empirical analysis like done in this dissertation, shall be used to underline the importance of adjusting the priorities within the circular economy debate, including political agendas. Social practice based LCA should be used to bridge the gap between (transformative) words and (incremental) action in the context of circular

economy policies (Calisto-Friant et al., 2021) by enabling policy makers to environmentally assess transformative change.

The analysis of urban sharing might also be important for the discussion on topics and directions of circular economy, as it provides a practical example of what this rather abstract "transformational change" (European Commission, 2020) might look like. As already discussed, urban sharing is both, radical in its premise of a value proposition that puts enoughness against 'über-availability', but also not radical, as it picks up older models of life in communities and do-it-yourself ethics, which makes it so accessible.

Some critics of the reductionist reality of circular economy activities, propose a circular society, that focuses on the societal changes needed, that go beyond mere technological innovation. Jaeger-Erben et al. (2021) formulated four central topics for a "roadmap towards a Circular Society", that I will discuss in regard to the results of this dissertation:

1) **Revive the roots of Circular Economy:** This refers to systems theoretical thinking that balances ecological, social and technological systems. Urban sharing proved to address inter-human and humanity-nature relationships as aspects of community and environmentalism are symbiotically combined. "Care, connectivity and cooperation instead of neglect, separation and rivalry" (Jaeger-Erben et al., 2021) are pillars of urban sharing in the Arrenberg neighbourhood. However, theories of social practice do not capture the systems as such, so further analysis could be conducted here.
2) **Challenge and transform capitalist value definitions:** Urban sharing includes much work that does not add value in classical capitalist sense, which includes care work (e.g. foodsharing and the free barber shop), do-it-yourself activities (e.g. urban gardening) and community work (e.g. open restaurant day). Instead, social and ecological value is created. Urban gardeners were very explicit, that the whole undertaking would never be profitable, even though a cooperation with a local enterprise was tested. However, this dissertation does not include any analysis of formal negotiation of values. Which belief systems are reflected in the analysed urban sharing initiatives? Further research is necessary here, especially when urban sharing practices recruit more carriers.
3) **Negotiate and strengthen sufficiency strategies:** As primarily discussed in publication B, urban sharing is heavily sufficiency oriented. Not using and producing stuff is generally environmentally superior to efficient or effective handling of said stuff. This is the reason why the strategies of refuse, rethink and reduce are said to inherit the highest environmental potential of all value retention options.
4) **Foster agency rather than passivity:** Urban sharing is based on people getting active themselves, to bring in what they do and like best. The whole Arrenberg Initiative is basically a big enabler by providing basic physical and organizational infrastructure.

> There is no central body or entrepreneur that provides the neighbourhood with sufficiency, but instead the citizens are invited to do it themselves. The whole development of narratives of change and place is dependent on people meeting, cooperating, co-designing and co-producing. Several interviewees described their beginning in urban sharing with a personal initial idea that was presented to the Arrenberg Initiative organizers, who then just supported this initiative by providing space or market the idea. People who wanted to have cloths sharing, then had to organize it themselves, which is also true for free barber shop etc.

There is a strong overlapping between the proposed central topics for a circular society and the empirical results on urban sharing. As there is an additional environmental assessment that proves the environmental relevance of urban sharing, it can be concluded that this dissertation backs the importance of the circular society concept to work towards sustainability. However, as urban sharing was analysed in relatively small case, systemic effects on economy and culture could not be observed for the case of broad societal diffusion of urban sharing. The macroeconomic consequences of applied sufficiency, the mode of negotiation of transforming values are issues that need to be further addressed by academia and society.

6 Conclusion

Currently, the circular economy lacks behind its promises of radically cutting resource demand and reducing corresponding environmental impacts. One reason is the focus on incremental technological change, while neglecting transformative measure, e.g. in the realm of sufficiency, to change our consumption system. In order to promote a broadened view on circularity which includes the transformation of consumption cultures, a methodology to comprehensively assess the environmental potential of urban sharing was presented. Three research questions were addressed throughout this endeavor and in the course of three peer-reviewed publications:

1. Social practice based LCA (RQ1): A new methodological approach, social practice-based life cycle assessment was presented in order to environmentally assess transformative change in our consumption system by looking at and understanding social embeddedness and connecting comprehensive social systems (nexus of social practices) to supply chains.
2. On urban sharing (RQ2): Qualitative empirical analysis was conducted to understand the meanings of urban sharing, primarily notions of enoughness, and how it is embedded in daily life, especially to grocery shopping, travelling and urban mobility. This nexus of social practices delivers the system boundaries for quantitative environmental assessments.
3. LCA of urban sharing (RQ3): The LCA of urban sharing showed a high environmental potential of urban sharing as its meaning of enough transcends through a nexus of environmentally relevant social practices.

It was shown, that for a comprehensive assessment of social phenomena, such as urban sharing, interdisciplinary approaches are necessary to identify correct system boundaries and formulate relevant research questions. Theories of social practices were used to provide a theoretical basis for the conceptualisation of daily life and its embeddedness in nexuses of social practices, which helps to formulate relevant research questions and to identify system boundaries.

Urban sharing then proved to be a powerful emerging social practice as it supports a good life by shifting the value proposition from material growth to belonging in a community, material enoughness and learning. The sufficiency-oriented meanings of sharing were shown to have traveled through the nexus of practices and affected shopping groceries, travelling and urban mobility. Important for the development of urban sharing are third places, an active citizenship and mutual narratives of place and change. This deeper cultural shift

points at the transformative potential of urban sharing in regard to our consumption system, which addresses the gap in current circular economy related strategies and measures.

Using the proposed social practice-based life cycle assessment was able to environmentally assess urban sharing comprehensively by including the whole nexus of urban sharing within the system boundaries. It could be shown that the environmental potential of urban sharing does not simply lie in efficient use of resources, as promised by the sharing economy, but in the renegotiation of the commodity fetishism when it travels through daily life. Around 1.5 tons CO_2-eq. per person and year could be saved when urban sharing establishes in daily life, which is to a large extent explained by a shift in food consumption patterns.

The hypothesis was confirmed in two ways: first, by presenting a methodological framework that, based on theoretical discussions of the social world and the nexus of social practices, introduces a new dimension of comprehensiveness; and second, by providing the empirical case of urban sharing, identifying environmental impacts that are rooted in its meanings and nexus of social practices—impacts that would otherwise have been overlooked.

By providing a sufficiency-oriented empirical case and a mixed-method methodology for the environmental assessment, this dissertation supports the discourse on circularity, by showing ways to re-arrange the priorities in academia and politics to drastically cut environmental impacts from our consumption system.

References

Acquier, A., Daudigeos, T., Pinkse, J., 2017. Promises and paradoxes of the sharing economy: An organizing framework. Technological Forecasting and Social Change 125, 1–10. https://doi.org/10.1016/j.techfore.2017.07.006

Agarwal, N., Steinmetz, R., 2019. Sharing Economy: A Systemic Literature Review. International Journal of Innovation and Technology Management 16 (6). https://doi.org/10.1142/S0219877019300027

Andreoni, V., 2020. The Trap of Success: A Paradox of Scale for Sharing Economy and Degrowth. Sustainability 12 (8), 3153. https://doi.org/10.3390/su12083153

Augenstein, J.-P.D.K., Bachmann, B., Hermelingmeier, V., Kessler, A., Palzkill, A., Suski, P., 2020. Urban Sharing Society: Teilen und Teilhabe als Leitprinzipien nachhaltiger Stadtentwicklung (UrbanUp Working Paper No. 1). transzent - Zentrum für Transformationsforschung und Nachhaltigkeit, Wuppertal.

Belk, R., 2007. Why Not Share Rather Than Own? The ANNALS of the American Academy of Political and Social Science 611, 126–140. https://doi.org/10.1177/0002716206298483

Belk, R., 2014. You are what you can access: Sharing and collaborative consumption online. Journal of Business Research 67 (8). 1595-1600. 10.1016/j.jbusres.2013.10.001

Berkhout, P.H.G., Muskens, J.C., W. Velthuijsen, J., 2000. Defining the rebound effect. Energy Policy 28, 425–432. https://doi.org/10.1016/S0301-4215(00)00022-7

Bienge, K., Clausen, J., Suski, P., Schmitt, M., 2019. Ecological and socio-technical assessment of collaborative consumption: resource efficiency potentials. NachhaltigkeitsManagementForum | Sustainability Management Forum 27, 139–149. https://doi.org/10.1007/s00550-019-00489-7

Brand, U., Wissen, M., 2017. Social-Ecological Transformation, in: Richardson, D., Castree, N., Goodchild, M.F., Kobayashi, A., Liu, W., Marston, R.A. (Eds.), International Encyclopedia of Geography. Wiley, pp. 1–9. https://doi.org/10.1002/9781118786352.wbieg0690

Buhl, J., Acosta, J., 2016a. Work less, do less?: Working time reductions and rebound effects. Sustainability Science 11, 261–276. https://doi.org/10.1007/s11625-015-0322-8

Buhl, J., Acosta, J., 2016b. Indirect Effects from Resource Sufficiency Behaviour in Germany, in: Rethinking Climate and Energy Policies - New Perspectives on the Rebound Phenomenon.

Buhl, J., Liedtke, C., Bienge, K., 2017. How Much Environment Do Humans Need? Evidence from an Integrated Online User Application Linking Natural Resource Use and Subjective Well-Being in Germany. Resources 6, 67. https://doi.org/10.3390/resources6040067

Calisto Friant, M., 2022. From Circular Economy to Circular Society: Analysing Circularity Discourses and Policies and Their Sustainability Implications. Utrecht University. https://doi.org/10.33540/1562

Calisto Friant, M., Vermeulen, W.J.V., Salomone, R., 2023. Transition to a Sustainable Circular Society: More than Just Resource Efficiency. Circ.Econ.Sust. https://doi.org/10.1007/s43615-023-00272-3

Calisto Friant, M., Vermeulen, W.J.V., Salomone, R., 2021. Analysing European Union circular economy policies: words versus actions. Sustainable Production and Consumption 27, 337–353. https://doi.org/10.1016/j.spc.2020.11.001

Calisto Friant, M., Vermeulen, W.J.V., Salomone, R., 2020. A typology of circular economy discourses: Navigating the diverse visions of a contested paradigm. Resources, Conservation and Recycling 161, 104917. https://doi.org/10.1016/j.resconrec.2020.104917

Callon, M., 1986. The Sociology of an Actor-Network: The Case of the Electric Vehicle, in: Callon, M., Law, J., Rip, A. (Eds.), Mapping the Dynamics of Science and Technology. Palgrave Macmillan UK, London, pp. 19–34. https://doi.org/10.1007/978-1-349-07408-2_2

Celata, F., Stabrowski, F., 2022. Crowds, communities, (post)capitalism and the sharing economy. City 26, 119–127. https://doi.org/10.1080/13604813.2021.2018846

Curtis, C., Olaru, D., Smith, B., Reed, T. W., Knight, C., Biermann, S., 2025. Sustainable urban mobility transitions through working from home (WFH). In: Travel Behaviour and Society 39, S. 100953. DOI: 10.1016/j.tbs.2024.100953.

Droege, H., Kirchherr, J., Raggi, A., Ramos, T.B., 2023. Towards a circular disruption: On the pivotal role of circular economy policy entrepreneurs. Bus Strat Env 32, 1142–1158. https://doi.org/10.1002/bse.3098

Durkheim, E., 1982. The rules of sociological method, 1st American ed. ed. Free Press, New York.

Elkington, J., 2018. 25 Years Ago I Coined the Phrase "Triple Bottom Line." Here's Why It's Time to Rethink It. Harvard Business Review.

Elkington, J., 1994. Towards the Sustainable Corporation: Win-Win-Win Business Strategies for Sustainable Development. California Management Review 36, 90–100. https://doi.org/10.2307/41165746

Elkington, J., Burke, T., 1987. The green capitalists: industry's search for environmental excellence. Gollancz, London.

Ellsworth-Krebs, K., Niero, M., Jack, T., 2023. Feminist LCAs: Finding leverage points for wellbeing within planetary boundaries. Sustainable Production and Consumption 39, 546–555. https://doi.org/10.1016/j.spc.2023.05.035

European Commission, 2020. A new Circular Economy Action Plan - For a cleaner and more competetive Europe (Communication). Brussels.

European Commission (2021): Better Regulation Guidelines. Brussels.

European Environment Agency, 2018. Electric vehicles from life cycle and circular economy perspectives. TERM 2018: Transport and Environment Reporting Mechanism (TERM) report. doi:10.2800/77428

Fernando, C., Buttriss, G., Yoon, H.-J., Soo, V.K., Compston, P., Doolan, M., 2023. Integration of consumer preferences into dynamic life cycle assessment for the sharing economy: methodology and case study for shared mobility. Int J Life Cycle Assess 28, 429–461. https://doi.org/10.1007/s11367-023-02148-y

Font Vivanco, D., Kemp, R., van der Voet, E., 2015. The relativity of eco-innovation: environmental rebound effects from past transport innovations in Europe. Journal of Cleaner Production 101, 71–85. https://doi.org/10.1016/j.jclepro.2015.04.019

Font Vivanco, D., van der Voet, E., 2014. The rebound effect through industrial ecology's eyes: a review of LCA-based studies. The International Journal of Life Cycle Assessment 19, 1933–1947. https://doi.org/10.1007/s11367-014-0802-6

Frenken, K., Schor, J., 2017. Putting the sharing economy into perspective. Environmental Innovation and Societal Transitions, Sustainability Perspectives on the Sharing Economy 23, 3–10. https://doi.org/10.1016/j.eist.2017.01.003

Galvin, R., Gubernat, A., 2016. The rebound effect and Schatzki's social theory: Reassessing the socio-materiality of energy consumption via a German case study. In: Energy Research & Social Science 22, S. 183–193. DOI: 10.1016/j.erss.2016.08.024.

Geels, F. W., 2010. Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. In: Research Policy 39 (4), S. 495–510. DOI: 10.1016/j.respol.2010.01.022.

Giddens, A., 1984. The constitution of society. Outline of the theory of structuration. University of California Press, Berkeley.

Giddens, A., 1979. Central problems in social theory: action, structure and contradiction in social analysis, Nachdr. ed, Contemporary social theory. Macmillan, Basingstoke.

Goosen, Z., Cilliers, E.J., 2020. Enhancing Social Sustainability Through the Planning of Third Places: A Theory-Based Framework. Soc Indic Res 150, 835–866. https://doi.org/10.1007/s11205-020-02350-7

Govindan, K., Shankar, K.M., Kannan, D., 2020. Achieving sustainable development goals through identifying and analyzing barriers to industrial sharing economy: A framework development. International Journal of Production Economics 227, 107575. https://doi.org/10.1016/j.ijpe.2019.107575

Greene, M., Hobson, K., Jaeger-Erben, M., 2024. Bringing the circular economy home – Insights from socio-technical perspectives on everyday consumption. Cleaner and Responsible Consumption 12, 100157. https://doi.org/10.1016/j.clrc.2023.100157

Greiff, K., Teubler, J., Baedeker, C., Liedtke, C., Rohn, H., 2016. Material and carbon footprint of household activities.

Haas, B., 2017. Chinese bike share graveyard a monument to industry's "arrogance." The Guardian.

Haberl, H., Schmid, M., Haas, W., Wiedenhofer, D., Rau, H., Winiwarter, V., 2021. Stocks, flows, services and practices: Nexus approaches to sustainable social metabolism. In: *Ecological Economics* 182, S. 106949. DOI: 10.1016/j.ecolecon.2021.106949.

Haberl, H., Wiedenhofer, D., Virág, D., Kalt, G., Plank, B., Brockway, P. et al. 2020. A systematic review of the evidence on decoupling of GDP, resource use and GHG emissions, part II: synthesizing the insights. In: Environ. Res. Lett. 15 (6), S. 65003. DOI: 10.1088/1748-9326/ab842a.

Harris, S., Mata, E., Plepys, A., Cecilia, K., 2021. Sharing is daring, but is it usstainable? An assessment of sharing cars, electric tools and offices in Sweden. Resources, Conservation and Recycling 170, 105583. DOI: 10.1016/j.resconrec.2021.105583.

Hellmann, D.M., Fiedler, S., Glöckner, A., 2021. Altruistic Giving Toward Refugees: Identifying Factors That Increase Citizens' Willingness to Help. Front. Psychol. 12, 689184. https://doi.org/10.3389/fpsyg.2021.689184

Hilty, L.M., Aebischer, B., 2015. ICT for Sustainability: An Emerging Research Field, in: Hilty, L.M., Aebischer, B. (Eds.), ICT Innovations for Sustainability. Springer International Publishing, Cham, pp. 3–36. https://doi.org/10.1007/978-3-319-09228-7_1

Hölscher, K., Wittmayer, J.M., Loorbach, D., 2018. Transition versus transformation: What's the difference? Environmental Innovation and Societal Transitions 27, 1–3. https://doi.org/10.1016/j.eist.2017.10.007

Hopwood, B., Mellor, M., O'Brien, G., 2005. Sustainable development: mapping different approaches. Sust. Dev. 13, 38–52. https://doi.org/10.1002/sd.244

Horkheimer, M., Adorno, T.W., Schmid Noerr, G., 2002. Dialectic of enlightenment: philosophical fragments, Cultural memory in the present. Stanford University Press, Stanford, Calif.

ISO, 2006. ISO 14040:2006 Environmental management -- Life cycle assessment -- Principles and framework. International Standard Organisation.

Jaeger-Erben, M., Jensen, C., Hofmann, F., Zwiers, J., 2021. There is no sustainable circular economy without a circular society. Resources, Conservation and Recycling 168, 105476. https://doi.org/10.1016/j.resconrec.2021.105476

Jaeger-Erben, M., Rückert-John, J., Schäfer, M., 2015. Sustainable consumption through social innovation: a typology of innovations for sustainable consumption practices. Journal of Cleaner Production 108, 784–798. https://doi.org/10.1016/j.jclepro.2015.07.042

Jarašūnienė, A., Česnulaitis, D., 2023. The application of sustainable mobility and multimodality opportunities based on the example of Vilnius city. In: Transportation Research Procedia 72, S. 4366–4373. DOI: 10.1016/j.trpro.2023.11.332.

Jeffres, L.W., Bracken, C.C., Jian, G., Casey, M.F., 2009. The Impact of Third Places on Community Quality of Life. Applied Research Quality Life 4, 333–345. https://doi.org/10.1007/s11482-009-9084-8

Jevons, W.S., 1865. The Coal Question. Macmillan, London.

Joas, H., Knöbl, W., 2014. Social Theory: Twenty Introductory Lectures. Cambridge University Press.
John, N.A., 2017. The age of sharing. Polity, Malden, MA.
Kennedy, E.H., Cohen, M.J., Krogman, N.T., 2015. Social practice theories and research on sustainable consumption, in: Putting Sustainability into Practice. Edward Elgar Publishing, pp. 3–22. https://doi.org/10.4337/9781784710606.00009
Kirchherr, J., Urbinati, A., Hartley, K., 2023. Circular economy: A new research field? J of Industrial Ecology jiec.13426. https://doi.org/10.1111/jiec.13426
Latour, B., 1996. On Actor-Network Theory: A Fey Clarifications. Soziale Welt 47, 369–81. http://www.jstor.org/stable/40878163.
Lave, J., Wenger, E., 1991. Situated learning: legitimate peripheral participation, Learning in doing. Cambridge University Press, Cambridge [England] ; New York.
Little, D., 1991. Varieties of social explanation: an introduction to the philosophy of social science. Westview Press, Boulder.
Lorek, Sylvia; Spangenberg, Joachim H. (2014): Sustainable consumption within a sustainable economy – beyond green growth and green economies. In: Journal of Cleaner Production 63, S. 33–44. DOI: 10.1016/j.jclepro.2013.08.045.
Marx, K., 1867. Capital (Vol. 1). Penguin, London, England.
Meshulam, T., Font-Vivanco, D., Blass, V., Makov, T., 2023. Sharing economy rebound: The case of peer-to-peer sharing of food waste. J of Industrial Ecology 27, 882–895. https://doi.org/10.1111/jiec.13319
Mi, Z., Coffman, D., 2019. The sharing economy promotes sustainable societies. Nat Commun 10, 1214. https://doi.org/10.1038/s41467-019-09260-4
Miller, S.A., Keoleian, G.A., 2015. Framework for Analyzing Transformative Technologies in Life Cycle Assessment. Environmental Science & Technology 49, 3067–3075. https://doi.org/10.1021/es505217a
Mock, M., 2020. Verantwortliches Individuum? Die (Un-)Haltbarkeit der Erzählung von der Konsument*innenverantwortung, in: Nachhaltige Nicht-Nachhaltigkeit. transcript Verlag, pp. 245–272. https://doi.org/10.1515/9783839454428-010
Nansubuga, B., Kowalkowski, C., 2021. Carsharing: a systematic literature review and research agenda. JOSM 32, 55–91. https://doi.org/10.1108/JOSM-10-2020-0344
Nasehi, H., Saberi, H., Ghaedrahmati, S., Khademolhoosini, A., 2023. Social sustainability and urban third places: the case of the city of Isfahan in Iran. GeoJournal. https://doi.org/10.1007/s10708-023-10839-0
Niero, M., 2023. Implementation of the European Union´s packaging and packaging waste regulation: A decision support framework combining quantitative environmental sustainability assessment methods and socio-technical approaches. Cleaner Waste Systems 6, 100112. https://doi.org/10.1016/j.clwas.2023.100112
Niero, M., Jensen, C.L., Fratini, C.F., Dorland, J., Jørgensen, M.S., Georg, S., 2021. Is life cycle assessment enough to address unintended side effects from Circular Economy initiatives? Journal of Industrial Ecology 25, 1111–1120. https://doi.org/10.1111/jiec.13134
Parrique, T., Barth, J., Briens, F., Kerschner, C., Kraus-Polk, A., Kuokkanen, A., Spangenberg, J.H., 2019. Decoupling debunked: Evidence and arguments against green growth as a sole strategy for sustainability. European Environmental Bureau. Online verfügbar unter eeb.org/library/decoupling-debunked.
Piontek, F.M., Amasawa, E., Kimita, K., 2020. Environmental implication of casual wear rental services: Case of Japan and Germany. Procedia CIRP 90, 724–729. https://doi.org/10.1016/j.procir.2020.01.076
Pohl, J., 2022. Integration of higher-order effects into life cycle assessment of information and communication technology. https://doi.org/10.14279/DEPOSITONCE-16451
Pohl, J., Frick, V., Hoefner, A., Santarius, T., Finkbeiner, M., 2021. Environmental saving potentials of a smart home system from a life cycle perspective: How green is the smart home? Journal of Cleaner Production 312, 127845. https://doi.org/10.1016/j.jclepro.2021.127845

Pohl, J., Hilty, L.M., Finkbeiner, M., 2019. How LCA contributes to the environmental assessment of higher order effects of ICT application: A review of different approaches. Journal of Cleaner Production 219, 698–712. https://doi.org/10.1016/j.jclepro.2019.02.018

Polizzi di Sorrentino, E., Woelbert, E., Sala, S., 2016. Consumers and their behavior: state of the art in behavioral science supporting use phase modeling in LCA and ecodesign. The International Journal of Life Cycle Assessment 21, 237–251. https://doi.org/10.1007/s11367-015-1016-2

Potting, J., Hekkert, M., Worrell, E., Hanemaaijer, A., 2017. Circular Economy: Measuring Innovation in the Production Chain. PBL Netherlands Environmental Assessment Agency, The Hague.

Reckwitz, A., 2002. Toward a Theory of Social Practices: A Development in Culturalist Theorizing. European Journal of Social Theory 5, 243–263. https://doi.org/10.1177/13684310222225432

Reike, D., Vermeulen, W.J.V., Witjes, S., 2018. The circular economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. Resources, Conservation and Recycling 135, 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027

Reimers, H., Jacksohn, A., Appenfeller, D., Lasarov, W., Hüttel, A., Rehdanz, K., Balderjahn, I., Hoffmann, S., 2021. Indirect rebound effects on the consumer level: A state-of-the-art literature review. Cleaner and Responsible Consumption 3, 100032. https://doi.org/10.1016/j.clrc.2021.100032

Richardson, L., 2015. Performing the sharing economy. GEOFORUM 67, 121–129. https://doi.org/10.1016/j.geoforum.2015.11.004

Schatzki, T., 2016. Practice theory as flat ontology, in: Practice Theory and Research: Exploring the Dynamics of Social Life. Routledge.

Schatzki, T.R., 1996. Social practices: A Wittgensteinian approach to human activity and the social. Cambridge University Press.

Schneidewind, Uwe; Augenstein, Karoline (2016): Three Schools of Transformation Thinking: The Impact of Ideas, Institutions, and Technological Innovation on Transformation Processes. In: GAIA - Ecological Perspectives for Science and Society 25 (2), S. 88–93. DOI: 10.14512/gaia.25.2.7.

Scholl, G., Behrendt, S., Gossen, M., Henseling, C., Ludmann, S., Pentzien, J., Peuckert, J., 2018. Ökobilanz der *sharing economy:* Teilen allein nützt der Umwelt wenig. GAIA - Ecological Perspectives for Science and Society 27, 176–177. https://doi.org/10.14512/gaia.27.1.14

Shove, E., 2010. Beyond the ABC: Climate Change Policy and Theories of Social Change. Environment and Planning A 42, 1273–1285. https://doi.org/10.1068/a42282

Shove, E., Pantzar, M., Watson, M., 2012. The dynamics of social practice: everyday life and how it changes. SAGE, Los Angeles.

Sonnberger, M., Gross, M., 2018. Rebound Effects in Practice: An Invitation to Consider Rebound From a Practice Theory Perspective. Ecological Economics 154, 14–21. https://doi.org/10.1016/j.ecolecon.2018.07.013

Speck, M., Hasselkuss, M., 2015. Sufficiency in social practice: searching potentials for sufficient behavior in a consumerist culture. Sustainability: Science, Practice and Policy 11, 14–32. https://doi.org/10.1080/15487733.2015.11908143

Spurling, N.J., McMeekin, A., Southerton, D., Shove, E.A., Welch, D., 2013. Interventions in practice: reframing policy approaches to consumer behaviour. Sustainable practices research group.

Srnicek, N., 2017. The challenges of platform capitalism: understanding the logic of a new business model [WWW Document]. IPPR. URL https://www.ippr.org/juncture-item/the-challenges-of-platform-capitalism (accessed 9.2.23).

Stouten, P., 2012. The New Charter of Athens: Towards Sustainable Neighbourhoods? In: Built Eviron 38 (4), S. 497–507. DOI: 10.2148/benv.38.4.497.

Sun, S., Wu, Q., Tian, X., 2023. How does sharing economy advance cleaner production? Evidence from the product life cycle design perspective. Environmental Impact Assessment Review 99, 107016. https://doi.org/10.1016/j.eiar.2022.107016

Suski, P., Pohl, J., Frick, V., 2020. All you can stream: Investigating the role of user behavior for greenhouse gas intensity of video streaming, in: Proceedings of the 7th International Conference on ICT for Sustainability. Presented at the ICT4S2020: 7th International Conference on ICT for Sustainability, ACM, Bristol United Kingdom, pp. 128–138. https://doi.org/10.1145/3401335.3401709

Thornhill, C., 2013. Luhmann's social theory, in: Encyclopedia of Philosphy and the Social Sciences. SAGE Publications, California, USA.

van Lier, Tom; Witte, Astrid de; Macharis, Cathy (2014): How worthwhile is teleworking from a sustainable mobility perspective? The case of Brussels Capital region. In: European Journal of Transport and Infrastructure Research. DOI: 10.18757/ejtir.2014.14.3.3033.

Vita, Gibran; Lundström, Johan R.; Hertwich, Edgar G.; Quist, Jaco; Ivanova, Diana; Stadler, Konstantin; Wood, Richard (2019): The Environmental Impact of Green Consumption and Sufficiency Lifestyles Scenarios in Europe: Connecting Local Sustainability Visions to Global Consequences. In: *Ecological Economics* 164, S. 106322. DOI: 10.1016/j.ecolecon.2019.05.002.

Warde, A., 2022. Society and consumption. In: Consumption and Society 1 (1), S. 11–30. DOI: 10.1332/GTYE7193.

Welch, D., Keller, M., Mandich, G., 2017. Imagined futures of everyday life in the circular economy. interactions 24, 46–51. https://doi.org/10.1145/3047415

Zamagni, A., Guinée, J., Heijungs, R., Masoni, P., Raggi, A., 2012. Lights and shadows in consequential LCA. The International Journal of Life Cycle Assessment 17, 904–918. https://doi.org/10.1007/s11367-012-0423-x

Zhang, C., Hu, M., Di Maio, F., Sprecher, B., Yang, X., Tukker, A., 2022. An overview of the waste hierarchy framework for analyzing the circularity in construction and demolition waste management in Europe. Science of The Total Environment 803, 149892. https://doi.org/10.1016/j.scitotenv.2021.149892

Zhu, J., Marjanovic, O., 2021. A Different Kind of Sharing Economy: A Literature Review of Platform Cooperatives. Presented at the Hawaii International Conference on System Sciences. https://doi.org/10.24251/HICSS.2021.502