



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.

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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. Biengen 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, car-sharing, 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 (Dae 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 (Biengen 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 (Santariou 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. Biengen 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 Röpke 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 routinized 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

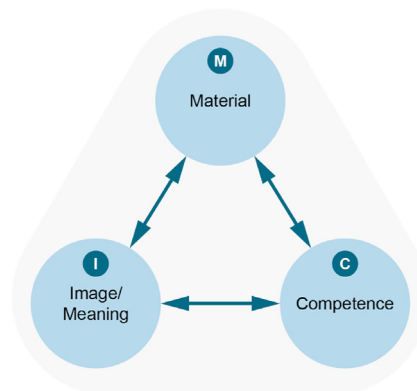


Fig. 1. Social practice comprising Image/Meaning, Competence, and Material (own depiction, based on Shove et al., 2012).

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.

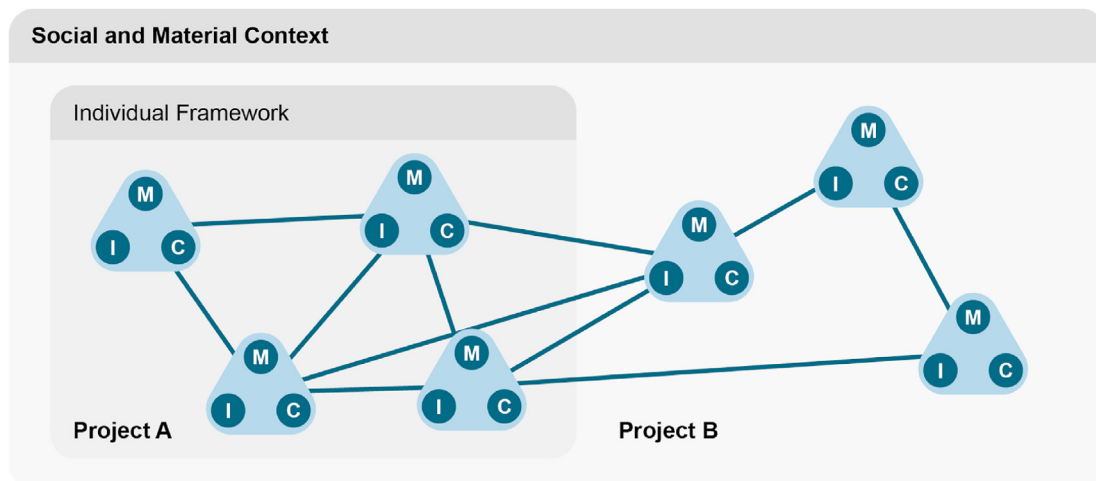


Fig. 2. Practices, projects, and frameworks; M: Material; I: Image/Meaning; C: Competence (own depiction based on Røpke and Christensen, 2012).

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 disbanded 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

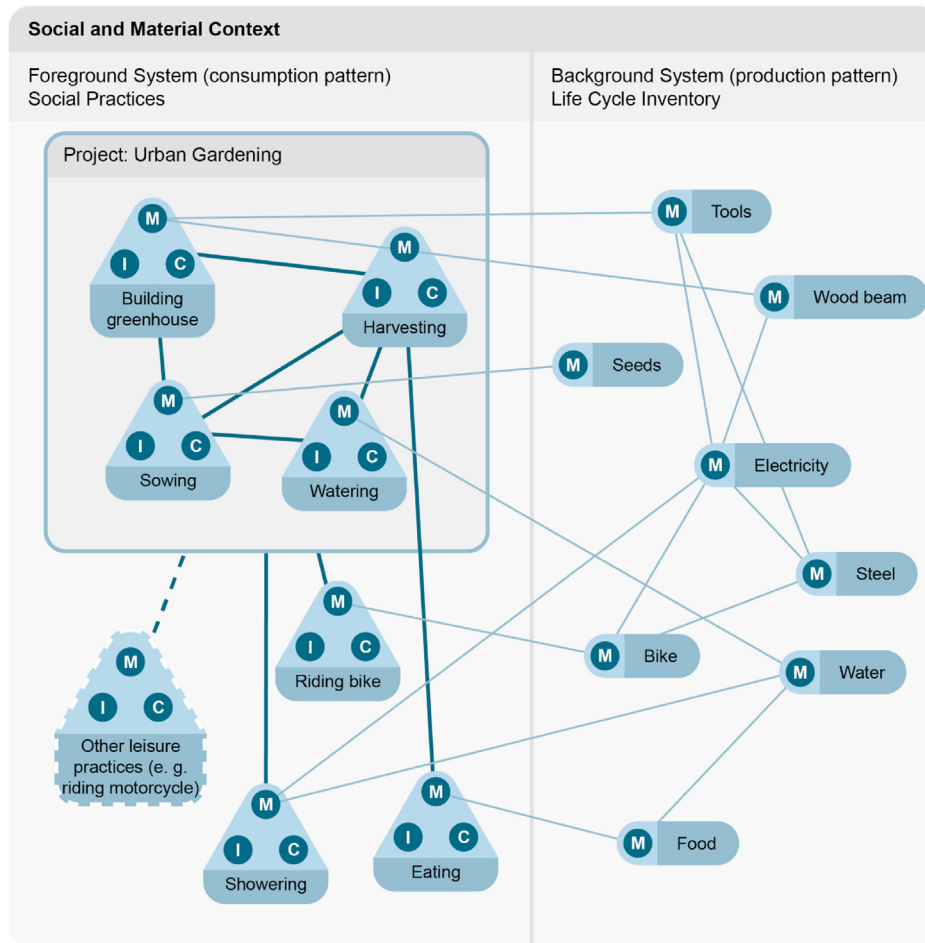


Fig. 3. Social practice based framework for LCA. Consumption pattern is described by interlinked social practices; production pattern is described by material flows in accordance with LCA. Practices not pursued because of the practice(s) under investigation are displayed in dashed lines.

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, sub-practices, 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

Paul 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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