



# Processes of sustainability transformation across systems scales: leveraging systemic change in the textile sector

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## Abstract

Sustainability research emphasizes the importance of intervening with both individual and organizational behaviours as well as the systems that shape them to create sustainability transformations. However, to date there is a lack of studies that bridge the divide between small case-based interventions and global systems at broader scales, and the complex interactions across scales and processes. This paper works with a leverage points framework to consider systems transformation. It focuses on four individual sustainability interventions in the textile sector and explores how they are embedded within a complex set of nested systems, and how these connected systems shape the transformative potential of the interventions. By using an onion metaphor for systems with several onion layers representing the current textile sector and its multiple connected and nested systems, we integrate and reflect across four in-depth case studies, conducted over a period of 3 years, using a range of empirical research approaches. The findings show that the studied interventions all target multiple deep leverage points within their target systems of production and consumption. All are limited in fulfilling their transformative potential by a range of barriers that we trace back to the economic and policy and regulation systems that they are embedded within. The economic system enforces a paradigm of consumption-based growth, and the policy and regulation system fails to either support change, or restrict unsustainable behaviours. Our findings demonstrate the need to think across systems scales to understand leverage points and transformative change; our nested systems approach is one way to do so. We outline two promising pathways for sustainability transformations: (1) focussing on how to create spillover effects of favourable interventions in sub-systems to push outwards against the constraints of the current policy and regulation, and economic systems; and (2) by targeting actors and interventions within the policy and regulation and economic systems to create change in the paradigms and design they embody and enforce on the systems nested within them.

**Keywords** Scaling · Climate change · Leverage points · Systems thinking · Degrowth

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## Introduction

To create sustainability transformations, we need to understand how individual interventions for sustainability are shaped by broader drivers and barriers that influence their growth, impact and longevity. Transformations are fundamental shifts in our behaviours and societies in the pursuit of sustainability (Scoones et al. 2020). Interventions for sustainability are actions that bear potential to transform systems in such a way that they contribute to sustainability (e.g. Abson et al. 2017). Existing research on transformations has a split between research that examines small-scale case-based examples of localised transformations and conceptual research that addresses the need for big global systems change (Salomaa and Juhola 2020). There is a need for bringing together these small-scale empirical contributions with such broad conceptual framings, alongside knowledge about how small-scale cases scale up (e.g. Moore et al. 2015; Lam et al. 2020). In particular, Feola (2021) and Bluwstein (2021) refer to the need for transformations research to explicitly address the role of the broader capitalist economic paradigms that interventions are embedded within. This implies a need to link between transformations within specific sectors and the broader social systems that they are embedded within. However, to date, there is a gap in empirical work that explicitly bridges these scales (Salomaa and Juhola 2020).

In this paper, we aim to bridge this gap by understanding the multi-layered system interactions that shape the transformative potential of sustainability interventions. We use an onion metaphor (Davelaar 2021) for systems with several onion layers representing the systems currently influencing the textile sector (see Sect. 2). Systems are interconnected networks of actors and organisations, connected via flows of materials, information, and power. Within a systems thinking perspective, we can understand systems to have properties of *materials*, *processes*, *design* and *paradigms* (Abson et al. 2017). These properties are points at which we can intervene to change the system towards more sustainable outcomes. Meadows (1999) describes these as leverage points and explains that intervening at deeper points (corresponding to the system properties of *design* and *paradigms*) creates more fundamental change than interventions at more shallow points targeting *processes* and *materials*. In reality, systems are multi-scalar, interconnected and complex (Meadows 2001; Davelaar 2021). Understanding processes of systems change therefore requires us to ‘dance with systems’ (Meadows 2001), meaning to learn from and engage with systems through dynamic, rather than static, perspectives, with passion and vision, to understand their functions or purposes and connections, and see how our values and the

system properties may interact (Meadows 2011; Constable et al. 2019). Interventions in deeper leverage points in one system (for example, a local, place-based intervention, or a change to production facilities) can therefore be constrained and shaped by the broader systems it is embedded within (e.g. an economic system). Therefore, a systems thinking approach requires us to understand the leverage points targeted by interventions in the system they are intervening in, and how they are embedded within, and interact with, other systems and their properties across time, space, and systems framings (Leventon et al. 2021).

We apply our systems thinking perspective to understand the transformative potential of interventions in the textiles sector. In doing so, we meet the calls of Fletcher (2009) to see the textiles sector as a complex system and to critique the leverage points targeted by interventions therein. The global textiles sector can be modelled as a whole system itself as a series of supply chain systems that demand resources and services from the ecological system, including modes of production, processing, transportation, consumption, and waste management. We thus consider the sector as incorporating multiple industries and defined systems (e.g. production, consumption), but also being a larger system of systems (e.g. how the production and consumption systems interact with each other), connected to a range of broader systems that cut across economic sectors (e.g. ecosystems, global markets, knowledge, cultural systems). This complexity across scales makes it an ideal case for understanding links between different scales of transformations. Furthermore, the sector is in acute need of transformation. It is characterised by high-throughput, low-quality products, representing the fourth highest pressure on resource use of EU household consumption domains (EEA 2023). Unsustainable outcomes are created throughout this sector, including labour rights violations, water and pesticides’ impact of e.g. cotton production (Partzsch et al. 2019), and the waste produced by fast fashion (e.g. Bick et al. 2018; Boström and Michelletti 2016; Ellen MacArthur Foundation 2017; Muthu 2017). The need to transform the textile sector is also well recognised as necessary to achieve the Sustainable Development Goals (Cai and Choi 2020; Gardetti and Muthu 2020).

To meet our aim, we examine four very different sustainability interventions in the textiles sector. Each of these cases has been studied in-depth by a member of the author team, as part of the project Processes of Sustainability Transformation (see acknowledgments). These cases are (a) the German Partnership for Sustainable Textiles (hereafter textiles partnership); (b) individual change agents for corporate sustainability in textile companies headquartered in Germany (hereafter individual change agents), (c) entrepreneurs performing in the sustainability fashion niche in Mexico (hereafter, sustainable ventures) and (d) sustainable chemistry (SC). The authors have studied the cases separately, as individual

and separate system interventions, recognising that they intervene in different parts of different textiles systems in different locations and contexts. By putting them together within this integrative paper, we can explore their connections within the “dynamic whole” (Fletcher 2009, p. 379) and consider if the whole is greater than the individual parts. We can see the wider system properties that they each target and identify common systems and their characteristics that shape their transformative potential. We therefore integrate these four case studies to address three research questions:

1. What leverage points, in what systems, do the case study interventions target?
2. What are the barriers to the interventions in fulfilling their transformative potential?
3. Which systems need to be targeted to remove these barriers?

In the remainder of the paper, we first outline our methodology for interrogating the case study interventions (“[Methodology and conceptual background](#)”). Here, we outline our conceptual framework of connected, nested systems and leverage points, introduce the case interventions, and explain our methods, which rely on integration and joint exploration of empirical research. This paper is the product of iterative discussions within the author team, held throughout a 3-year project where four of the authors each pursued their own in-depth case study. The results are therefore integrations across these case understandings from an expert-observer perspective, and reference is made to primary (published) results where necessary. “[Results](#)” addresses each research question in turn. In our “[Discussion](#)” section, we explore the relevance of our findings for the research and practice of transformations, both within the textiles sector and more broadly. We outline how systems thinking helps us to understand how individual interventions are shaped by broader systems conditions, and highlight where to intervene (which system, and which leverage points) to unlock more meaningful change. We outline how a systems thinking approach allows us to bridge across scales and systems of transformative change. In “[Conclusion](#)” we argue that sustainability transformations require interventions in economic paradigms to change the operating conditions across sectors.

## Methodology and conceptual background

### Conceptual framework: working with leverage points for systems change

In Meadows’ leverage points framework, she outlines that system properties are leverage points. We can intervene with these properties to create change. She originally identified

twelve leverage points, and these are condensed into four categories (Abson et al. 2017; Fischer and Riechers 2019; Leventon et al. 2021): (1) *materials*; (2) *processes*; (3) *design*; and (4) *paradigm*. Starting from the deepest, *paradigms* relate to the worldviews and paradigms that are being embodied and enacted by the system. *Design* refers to the structures, actors and organisations in the system and how they interact with each other. *Processes* refer to the feedbacks or procedures that move materials around the system, and *materials* are the flows of matters within the system, such as money or fabrics and other resources. Thus, the *paradigm* (what the system is seeking to achieve) shapes the *design* for delivering the system’s goals, which in turn shapes the *processes*, and they in turn shape *materials*. The leverage points framework makes clear that seeking to change *materials*, without changing e.g. *paradigms*, will create only small changes to the system initially. However, it is also possible that over time interventions in subsystems may create spillover effects to other system properties and other systems (Liu et al. 2015). Intervening in *paradigms* will create more rapid change to all system properties, and thus will fundamentally and rapidly transform the system.

Systems are connected. Davelaar (2021) outlines an onion metaphor to think about systems. In doing so, she outlines how inner systems are embedded within wider layers (systems) that shape and constrain the inner layers (systems) and vice versa. Thus, even an intervention at a deep leverage point in an inner system will be constrained by the outer layers of the onion. Creating transformation of the inner system therefore also requires transformation of the outer systems, suggesting that outer layers of the system and deeper leverage points in inner layers are somehow connected. In thinking about the textiles sector, we can refer to a whole range of nested, connected systems including production, transport, waste, consumption, legal and political, economic, cultural, social, and indeed the ecosystems within which raw materials are created. However, what these systems are, which is embedded within which, and even what they are called is contentious, and varies with perspective and problem framing (Ison 2008). Thus, despite the mechanical imagery of a leverage points framework, and the neatness of an ‘onion’ metaphor, we need to acknowledge that systems are not only ontological, realist objects, but are also epistemologies or framings. Indeed, Meadows referred to the ability to transcend *paradigms* as being the deepest leverage point of all, referring to the need to question our problem and systems framings (Meadows 1999). Therefore, it is difficult to pin down and describe ‘the’ system, and indeed, many researchers tend to use the framework as a boundary object,<sup>1</sup>

<sup>1</sup> After Trompette and Vinck 2009, we understand boundary objects as concepts that different researchers approach from different perspectives and understand differently, but can all work with and con-

**Fig. 1** Systems onion of the current textile sector, as envisioned by the author team. This shows the production system (represented by cogs and laboratory flasks) nested within a consumption system (represented by people—the retailers and consumers), nested within policy and regulatory systems (shown by article symbols), nested within an overarching economic system (represented by euro, dollar and pound signs). While we do not depict the ecological world within the system, it is assumed that it surrounds and permeates all layers of this systems onion



rather than an ontological framework (Fischer and Riechers 2019). Instead, we need to be skilled at questioning the system boundaries and connections, moving mentally through the different systems (Meadows 2001). What one researcher refers to as an intervention in one system may be framed by another as a system in itself (Leventon et al. 2021).

While recognising this normativity and subjectivity of systems and their framings, as an author team we started with an outline understanding of the textiles sector as a global nested set of systems (see Fig. 1). This system framing is a simplified model of a generalised system, noting that the details in each layer will look quite different (while sharing some common features) depending on location, product, etc. Here, we show the production system as the actors and entities that are involved in creating raw materials and manufacturing the final textile products. It encompasses international multi-tier supply chains (Govindan et al. 2021)

beginning with the growing of raw materials (like cotton), to all chemical processes, to fibre, yarn and fabric production and to the actual finishing of a clothing or textile product. It also includes the shipping and flying logistics to the importers and retailers and to the end consumer. The production system includes complex transnational business-to-business sales, distribution and trading relationships. This is embedded within a consumption system. The consumption system encompasses the sale of clothes in regional retail markets. It includes various forms of marketing and communication with consumers, and therefore incorporates wholesalers, retailers, consumers and marketing/advertising actors. Both these systems are in turn embedded within a policy and regulation system that shapes how products are produced and consumed. All aforementioned systems are encompassed by an economic system, which ultimately shapes the material relationship between society and nature, creates and hosts the market for textiles and the materials that are contained within, and indeed provides the conditions for what needs to be policed or regulated. Arguably, these systems are all embedded within a broader environmental, ecological

Footnote 1 (continued)

tribute to, in our own ways, to enhance overall understanding and learning.

system, and the ecological system underpins all layers of this onion.

We note that this is highly simplified, and we grappled with the systems that are not explicit within this onion (e.g. there is no waste system), and note that the order of layers is also not so clear cut (e.g. Is the economic system embedded within the policy system or vice versa; or are they actually intertwined?). Further, how each layer looks and is structured internally varies depending on the context, and therefore in the different cases we study. However, as a boundary object it serves to guide and structure discussions by pushing the authors to consider which system layer we are referring to, when, and in which case, despite our answers tangibly looking very different with our different methods and contexts. Therefore, even as a simplified heuristic, we found it a useful starting framework for understanding the systems and leverage points therein that are targeted by the four case interventions in the textiles sector. We questioned which systems they seek to intervene in (their target systems) and at what systems properties they target change (the leverage points), as well as how they intervene (after Leventon et al. 2021) to address research question 1. However, we also work backwards to identify what the barriers are to the studied interventions. To address research question 2, we then consider these barriers in terms of where they come from: which systems, and within them which system properties are creating these barriers. This allows us to identify the multi-scalar systems interactions that shape the transformative potential of our studied interventions and, ultimately, to consider where (in which systems and at what leverage points) to intervene to unlock broader transformative change.

## Data sources and methods

We draw on experiences and evidence from four case studies that all seek to foster sustainability within the textiles sector (see Table 1). We frame these cases as examples of interventions for sustainability transformations. Each of these cases has been studied by a separate member of the author team, taking a different perspective and methodological approach to understand the processes of transformation being created by the intervention (see Table 1, column 3). Our work in this paper extends our insights into a systems perspective that integrates across these diverse understandings. We therefore frame our methods for this current paper as being extensive discussions and workshops held through the duration of a 3-year project, with the focus on co-creating shared understandings.

These discussions took two forms. Initially, while the authors (excluding Leventon) were pursuing their separate research on the cases, discussions took place in the form of regular, largely informal meetings. Here, the authors met to share experiences, points of interest and problems in

conducting their research. These discussions created a foundation of learning to collaborate and co-create knowledge. They led the authors to identify this integrative paper, and a focus on systems thinking, as a point of common interest to which each author could contribute something meaningful, working with the leverage points framework as a boundary object (see e.g. Freeth and Caniglia 2019; Cuppen et al. 2021; Trompette and Vinck 2009). The author team (all authors) used their experiences and knowledge to interrogate each other and find common themes and understandings, while reflecting on systems thinking and leverage points questions outlined in Leventon et al. (2021). This reflection process meant that the authors could compare the results and implications of their separate research, despite taking very different methodological approaches (Table 1); discussions could focus on meanings and outcomes. The systems heuristic (Fig. 1) therefore provided an organising framework for integrating across different methodological traditions and theoretical positions. Discussions were recorded through notes by the author team, and each member used these to iteratively structure the paper and develop shared understandings of the conceptual framings (above). Through these more focussed discussions, each author returned to their own evidence (see Table 1, column 4) and experience to describe and critique their cases within this framework, and to compare across cases, meaning that outcomes all drew on empirical evidence from the cases.

Due to the subjectivity of what a system can be, we first focussed on explaining the target system of each case, and its boundaries to each other, as well as where they intervene (see also Fig. 1). By target system, we refer to the system that the case study intervention seeks to change. We reflected on the intervention itself, where it intervenes and what it seeks to achieve, by engaging with whom (or what) and within what boundaries. Through examining how it functions, we could explore what the system properties (as leverage points) are that the intervention targets within its target system (research question 1). These are interpretations made by the paper authors. It is therefore possible that the people within the case, and the designers or implementors of these interventions, would define target systems differently; such is the subjectivity and normativity of systems framings. Our interpretations are rather based on understandings gathered from across the respondents, data collected, and experiences we have in working with the case studies (see Table 1, column 4).

We continued by describing the barriers that were found to constrain the successes of our case interventions (research question 2). We asked ourselves, and each other, to consider two types of ‘failure’ to the transformative potential, inspired by Jordan et al.’s (1999) framework for failed policy

**Table 1** Case study interventions, their individual research focus, and methods

1. Case	2. Description	3. Research focus	4. Methods
A) Textiles partnership	<p>The concept of collaborative governance (Emerson et al. 2012; Driessen et al. 2012; Lange et al. 2013) in the textile sector provided the underlying framework from which a German multi-stakeholder initiative was studied as an interactive governance case. The partnership brings together more than 130 organisations and companies from seven stakeholder groups (government, business, industry associations, NGOs, trade unions, standards organisations, advisory members) and aims to improve social and environmental conditions in global textile production</p>	<p>First, the concept of collaborative governance was distinguished through a literature review, before examining a specific policy intervention case to explore the structures (policy), processes (politics), and contents (policy) of collaboration among actors within a specific partnership. The study addressed social networks, social learning, and private regulation in the sector</p>	<ul style="list-style-type: none"> <li>● Systematic literature review</li> <li>● In-depth case study</li> <li>● Social network analysis</li> <li>● Document analysis</li> <li>● Semi-structured interviews</li> <li>● Focus group discussion and reflection</li> </ul>
B) Individual change agents	<p>The behaviour of individual change agents, i.e. managers inside German textile producing and trading companies, who aim to, and are successful in, driving a sustainability transformation of their companies and the textile system to varying degrees. This includes all spheres of individual agency, i.e. their activities, beliefs, and motives (e.g. Buhr et al. 2023). The companies operate with multi-tier, international supply chains, which involve various business partners and stakeholders, including third parties, globally and especially in textile producing countries, such as Bangladesh, India, China, Vietnam, Pakistan, or Myanmar</p>	<p>This research explored the potential of individual change agents as a business intervention to drive sustainability transformations of companies. Based on a systematic literature review, individual change agent understandings were synthesized, a qualitative study explored sustainability managers' beliefs, and an in-depth case study of different textile companies focussed on the behaviour of individual change agents in a textile company. The companies interact with different textile sectors and markets (clothing, home textiles, shoes etc.)</p>	<ul style="list-style-type: none"> <li>● Systematic literature review</li> <li>● Semi-structured interviews</li> <li>● In-depth case study including semi-structured interviews, participatory observation, and document analysis</li> </ul>
C) Sustainable ventures	<p>Due to the negative socio-environmental impacts of (fast) fashion, areas of innovation and intervention for sustainability have emerged in fashion markets all around the world. Entrepreneurs in Mexico have been innovating with different products and services and positioning themselves in the market with the help of social media, while also raising awareness about the importance of sustainability</p>	<p>Focussing on entrepreneurs and their ventures as a business intervention, this research looks into the learning processes that led entrepreneurs to innovate in a sustainable fashion, such as low environmental impact materials, upcycled fabrics, and organic dyes, mostly in the clothing-apparel market. The venturing process of these entrepreneurs can be characterised as a transformative learning journey, where they have been able to reflect upon their expectations and practice in the fashion industry</p>	<ul style="list-style-type: none"> <li>● Systematic literature review: qualitative content analysis</li> <li>● Field observation</li> <li>● Exploratory multiple-case study</li> <li>● Semi-structured interviews</li> <li>● Snowball sampling using social media</li> <li>● Social media data mining</li> </ul>

**Table 1** (continued)

1. Case	2. Description	3. Research focus	4. Methods
D) Sustainable chemistry	The implementation of the concept of sustainable chemistry (SC) within the textile sector. Sustainable chemistry as a concept encompasses the entire life cycle of chemicals as well as technical and social dimensions, and offers a holistic framework to assess chemicals in the textile supply chain, their environmental effects as well as their social and economic aspects (e.g. Kümmerer 2017; Blum et al. 2017)	The potential of SC for the textile sector as an industry intervention was conceptually described and the current state of research on practices of sustainable and green chemistry in the textile sector was assessed. Subsequently, an experimental case study using complexing agents serves as a proof of principle of benign chemical design for the textile sector. Furthermore, the contribution of circular economy interventions (reuse and recycling) to reduced material flows and overall sustainability in the textile sector is assessed	<ul style="list-style-type: none"> <li>● Systematic literature review; quantitative data mining and qualitative content analysis</li> <li>● Systems thinking; SOCME mapping</li> </ul>

implementation. Jordan et al. (1999)<sup>2</sup> outline that policy implementation gaps can emerge when policy outcomes are (a) not able to achieve policy goals; and (b) not able to solve the problem that the policy sought to target. We therefore explored the barriers that shape (a) the successes and failures of the interventions to achieve their own sustainability goals and targets within their target system (for example, if the intervention can create the platform or product that it wants to create); and (b) whether or not such an intervention, even if perfectly implemented, can achieve a form of sustainability transformation at all. After identifying the barriers in this way, together we categorised them according to our understandings of which system property they came from, and in which system (research question 3). Similar to research question 1, this relied on the authors' interpretations and framings of systems. It is subjective, but serves as an interpretive framework to help unravel the complexities that transformative change must navigate.

## Results

### What leverage points, and in what systems, do the case interventions target?

#### Textiles partnership

The textiles partnership as a policy intervention has the production system as its primary target, but works through the consumption system to create this change (Table 2, row A). The production system is part of the stated aim of the partnership (shaping global textile production). In practice, the partnership includes the German organisations, companies, and brands that influence how textiles are produced. This can include government, business, industry associations, NGOs, trade unions, standards organisations, and advisory members including science actors. The mode of action for the partnership is to seek private, voluntary solutions through institutionalised negotiations and equal roles of representatives of the state, market and civil society, similar to other multi-stakeholder initiatives in other sectors (Jerbi 2012). Indeed, the partnership can be considered a system in itself, one that bridges across production, consumption, and policy systems. Due to the private nature of the partnership, less than 50% of the German turnover of the economic actors

<sup>2</sup> Jordan et al. (1999) identify four types of failed intervention. The first two are those identified in this paper. To create four, Jordan et al. further split both of these types into two, depending on if it is a failure of the policy output (e.g. the plan, programme, measure, etc.) or a failure of the policy outcome (the actions it results in). Such distinction was not so useful in this case, hence there is no further presentation of it in this current paper.

**Table 2** Case study interventions, their focal systems, and the leverage points that they intervene in

Case study interventions in the textile sector	Target systems	Leverage points (adapted from Abson et al. 2017)			
		1. Materials:	2. Processes:	3. Design:	4. Paradigm:
		flows of material within the system, such as money and other resources	the feedbacks or processes that move those materials around the system	structures, actors, and organizations in the system and how they interact with each other	the worldviews and paradigms that are being embodied and enacted by the system
<b>A. Textile partnership</b>	● Changes to the production system by changing the consumption system	<ul style="list-style-type: none"> <li>● Roadmaps on sustainability performance of all members serve as reporting obligation to evaluate sustainability efforts (currently involving companies that represent 50% of the German turnover of textiles)</li> </ul>	<ul style="list-style-type: none"> <li>● Social interaction and deliberation between representatives of different stakeholders as a leverage to create change</li> </ul>	<ul style="list-style-type: none"> <li>● Collaborative governance structures contain different forms of spaces for exchange (expert exchange to deepen sustainable production or political negotiations) between heterogeneous actors allowing for intense deliberation processes</li> </ul>	<ul style="list-style-type: none"> <li>● Intensive cooperation shifts underlying values and goals</li> <li>● Enhancing diversity of representatives for learning would help to overcome expert group thinking</li> </ul>
<b>B. Individual change agents</b>	<ul style="list-style-type: none"> <li>● Production system</li> <li>● Consumption system (indirectly)</li> </ul>	<ul style="list-style-type: none"> <li>● Use of chemicals</li> <li>● Type of textiles used</li> <li>● Choosing factories in production countries</li> <li>● Financial resources</li> </ul>	<ul style="list-style-type: none"> <li>● Partly influencing the way workers and ecosystems of the production system are treated</li> <li>● Enhance stakeholder interaction (internally colleagues and third parties, suppliers, customers, competitors, etc.) to push for sustainability efforts</li> </ul>	<ul style="list-style-type: none"> <li>● More sustainable corporate cultures and communication structures</li> <li>● Champion for increased certification systems, veto options, training and capacity development, etc.</li> </ul>	<ul style="list-style-type: none"> <li>● Altering culture, purposes, goals, business cases, and business models towards sustainability</li> </ul>
<b>C. Sustainable ventures</b>	<ul style="list-style-type: none"> <li>● Production system</li> <li>● Consumption system</li> </ul>	<ul style="list-style-type: none"> <li>● Technical innovations in garments and production processes</li> </ul>	<ul style="list-style-type: none"> <li>● Manufacturing processes such as upcycling</li> <li>● Business practices such as use of social media</li> </ul>	<ul style="list-style-type: none"> <li>● Structuring of new business models adapted to sustainability concerns</li> </ul>	<ul style="list-style-type: none"> <li>● Consumer expectations and wishes for sustainable fashion</li> <li>● Business practices and goals of sustainable entrepreneurs</li> </ul>
<b>D. Sustainable chemistry</b>	● Production system	<ul style="list-style-type: none"> <li>● Input prevention</li> <li>● New chemicals used in production</li> </ul>	<ul style="list-style-type: none"> <li>● Material circularity in recycling and reuse as CE strategies</li> </ul>	<ul style="list-style-type: none"> <li>● New infrastructure for new chemicals</li> </ul>	<ul style="list-style-type: none"> <li>● Entire life cycle of chemicals as well as technical and social dimensions</li> <li>● Embodying benign-by-design as a principle</li> <li>● Focus on function/service not chemical product</li> </ul>



**Fig. 2** Systems onion for the textiles partnership, showing actors in the consumption system working together to reach into the production system to create changes to the types of products and methods of production, and into the policy and regulation system to push for change



of the textile sector are currently involved, which means that the other 50% of the German turnover is represented by brands and retailers that are not involved in or affected by the joint decisions of the partnership. Participants are primarily German actors, and while some are producing textiles themselves, they also mainly represent retailers and brands that market textiles and are thus part of the consumption system. Many of these retailers work directly with primary producers outside of Germany that in turn work with secondary producers. Most of these business partners outside of Germany are not part of the formal structures of the partnership. In this way, the partnership creates changes to the conditions imposed upon the production system by the retailers, brands, and companies and thus to the consumption system (see Fig. 2). Further, the actors within the partnership advocate for greater regulations and voluntary standards across the sector. They thus push on policy systems to create change, and in turn these policy systems then stimulate and enforce changes to the consumption and production systems.

The textiles partnership targets multiple leverage points across these systems, seeking to ensure that shallower changes are strengthened by actions at deeper leverage points

in broader systems. *Materials* within the production system are targeted by annual roadmaps with which all members are to make their sustainability performance visible, based on global standards such as the UN Guiding Principles for Business and Human Rights (United Nations 2011). Concurrently, members co-create guidelines and standards that set voluntary principles for how textiles can be produced. Deeper leverage points are addressed within the system created by the partnership through the *design* of learning spaces of heterogeneous actors through forms of constructive conflict in the partnership (Beyers et al. 2021). This process of intensive cooperation is itself a reaction to changes happening within the underlying values and goals (*paradigms*) reflected by the actors in the partnership. These shifts are reflected, for example, in the motivation to be part of the partnership, as well as in a change in cooperation between NGO and company representatives to move away from competition and towards coordination and cooperation (Beyers et al. 2021). In principle, these learning opportunities inform the *design* of standards and push the members to innovate on how they define and meet sustainability, thus improving

**Fig. 3** Systems onion for individual change agents. The change agents work from within their target systems of production and consumption, pushing against dominant systems logic to change ways of doing and managing textile production and consumption



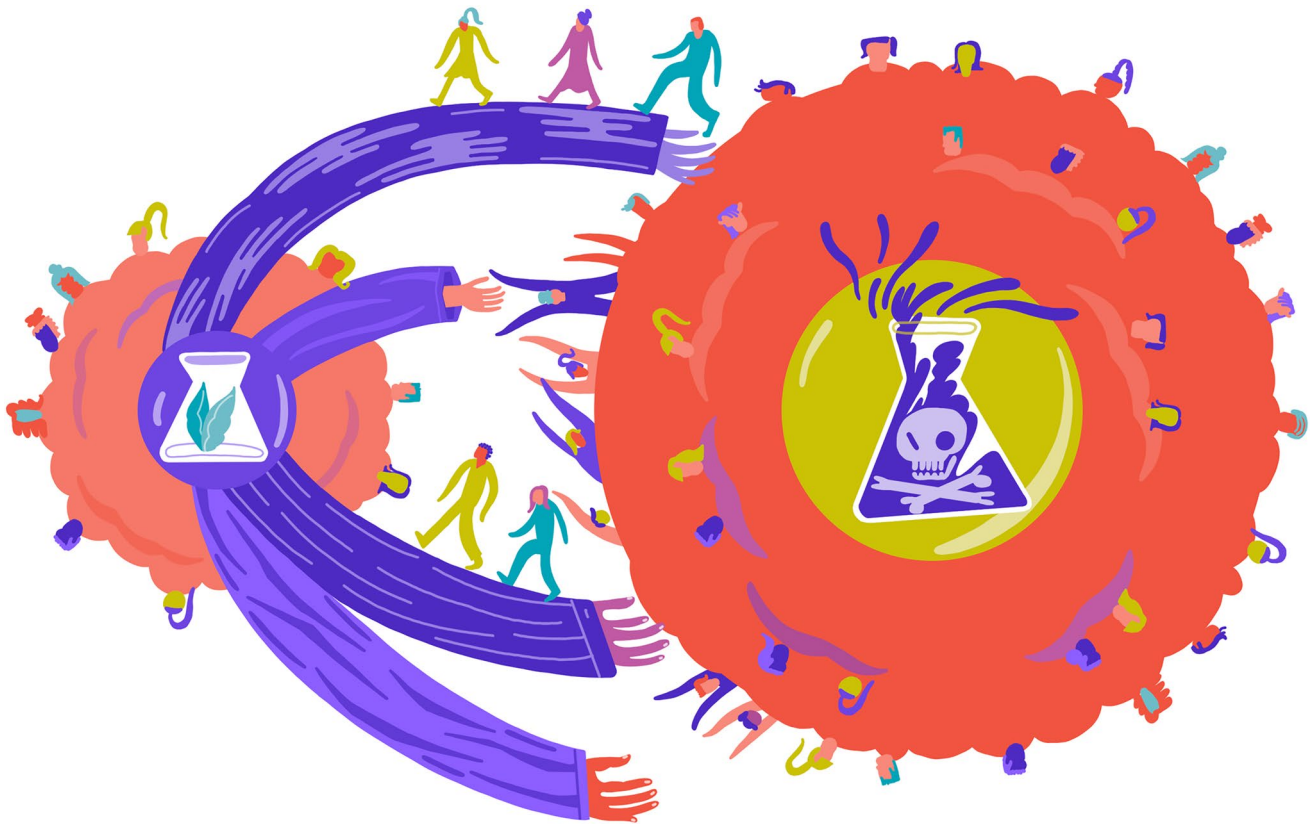
the scope and quality of the shallower interventions in the production system.

### Individual change agents

The individual change agents are managers inside German textile producing and trading companies and serve as a business intervention. They mainly target the production system in the producing countries (mostly countries of the Global South, such as Bangladesh, India, China, Vietnam, Pakistan, or Myanmar) and the consumption system in the consuming countries (mostly countries of the Global North, predominantly Germany and Europe) (Table 2, row B). The studied individual change agents work for companies or organisations within the production and consumption systems. They seek to create change initially within the practices of their own organisation, with the intention that these changes create knock-on impacts for other actors within the production and consumption systems (e.g. how textiles are produced, or the consumer demand for products) (see Fig. 3). For instance, in most cases they try to enhance internal and external stakeholder interaction, such

as engaging colleagues or third parties through collaboration to have stronger arguments for pushing sustainability efforts forward. This involves using fewer harmful chemicals, using different fabrics, or installing veto options for unsustainable purchasing practices. In addition, they try to create better working conditions for the textile workers and address how corporate cultures relate to sustainability.

Individual change agents are engaging with leverage points at different depths of the production and consumption system. They can push to change the *paradigm* of the company/organisation system by shaping the purpose, culture, and goals as well as core business models and stance of the company towards sustainability over time. This in turn can give greater legitimacy to the actions of the change agents and can amplify their interventions at the other identified leverage points. Individual change agents are working to alter the *design* of the system that is their own company or organisation. They do so by influencing corporate culture and communication structures, installing certification systems that manage and frame materials sustainably, and creating better working conditions through training and capacity development. On the level



**Fig. 4** Systems onion(s) for sustainable ventures. The sustainable ventures (left) offer new ways of producing and consuming textiles, and thus represent a new, alternative system. They then work to attract consumers from the existing, dominant and unsustainable system

of *processes*, individual change agents can, depending on their position in the company, affect internal processes and the interrelations with colleagues of the company, the way workers and ecosystems of the production system are treated, and they can directly interact with stakeholders including suppliers, third parties, workers, customers, and competitors. In doing so, change agents can also create change, or at least contribute to the *material* level of production systems. This is shown by changes to the types of textiles, financial resources, and also the factories in the countries where the textiles are produced.

### Sustainable ventures

The sustainable ventures case as a business intervention targets change in the consumption and production systems of textiles in Mexico, through the creation of a new, alternative market system (Table 2, row C). Here, entrepreneurs have become aware of the pitfalls of the current fashion industry and realise that they can contribute to transformation innovating in the manufacturing, retailing and marketing of sustainable fashion. Most of the entrepreneurs' ventures are brands whose business models are based on the use of

materials with a low environmental impact (organic fibres, upcycled fabrics, etc.) and retailing in e-commerce and social media platforms. The target of these entrepreneurs is thus to create a new system of production that then influences the practices of consumers, including their preferences and buying habits. As individual ventures have expanded and spread, they have also formed networks of collaboration through social media that have increased visibility and thus pulled more consumers to them (see Fig. 4).

Sustainable ventures initially intervene with the *paradigms* of the individual consumers within the textiles system. Each venture represents a different production system design and paradigm to those currently embedded within the global textiles system. They offer an alternative system for consumers to participate in and interact with. Therefore, a significant effort is made by the entrepreneurs to communicate sustainability and secure market position through consumer acceptance of their products. In doing so, the paradigms of the consumers themselves are shifted. However, social media such as Instagram also support the creation of a network of entrepreneurs and connections between ventures. In this way, the expectations and business practices amongst these ventures is also shifting (Rodríguez Aboytes et al. 2022). Thus there is an ongoing process of learning

amongst these ventures that is continually shaping the *design* of these alternative production systems.

### Sustainable chemistry

The sustainable chemistry case as an industry intervention concerns the material basis of the textile production system. Currently, the largely linear flow of material in the textiles sector creates depletion of natural resources, and an increase in pollution and waste. Due to the multitude and complexity of chemical substances used within the textile production process, each textiles product has its own chemical fingerprint with negative consequences (Kessler and Kuemmerer 2021). While the use and management of chemicals during the production process itself poses risk for ecosystems and human health in the producing countries, The individual chemical fingerprints of textiles becomes a health and environmental issue for people and ecosystems in consuming countries, as textiles still contain up to 90% of the chemicals used during manufacturing (Nimkar 2017). Once introduced into a process or product, chemicals or their transformation products are likely to remain a concern throughout the product's life cycle and beyond. Therefore, the use and management of chemicals in the production system define the pre-conditions for distribution, management, and health and environmental effects of these substances throughout the supply chain. The complexity of chemical composition and the globally intertwined supply chains face differing or absent national regulations for chemicals management, rendering it impossible to assess the holistic risk to ecosystems and human health, and to implement sustainable end-of-life treatment. Within the production system, sustainable chemistry focuses on input prevention of harmful chemicals and questions whether chemicals are always needed to deliver a textiles' function or appearance. By creating and using chemicals in production that are benign, the environmental impacts of production, consumption, and waste of textiles are reduced.

Sustainable chemistry most directly targets the leverage point of materials within the production system. Both input prevention and benign-by-design can be argued to target the *materials* of the system. However, they can also refer to a shift in *paradigms* within the system, as they reflect changes to the acceptability of chemicals within the system. Indeed 'benign-by-design' represents a paradigm that seeks to minimise harm and thus shape the design, processes, and materials of the production system. Further, in terms of targeting the paradigm of the system, sustainable chemistry reshapes the boundaries of what is included in the production system. Sustainable chemistry considers the contribution of reuse and recycling to the reduction of material flows and overall sustainability of the textile sector (Kessler et al. 2021). It thus bridges across two previously separated systems within

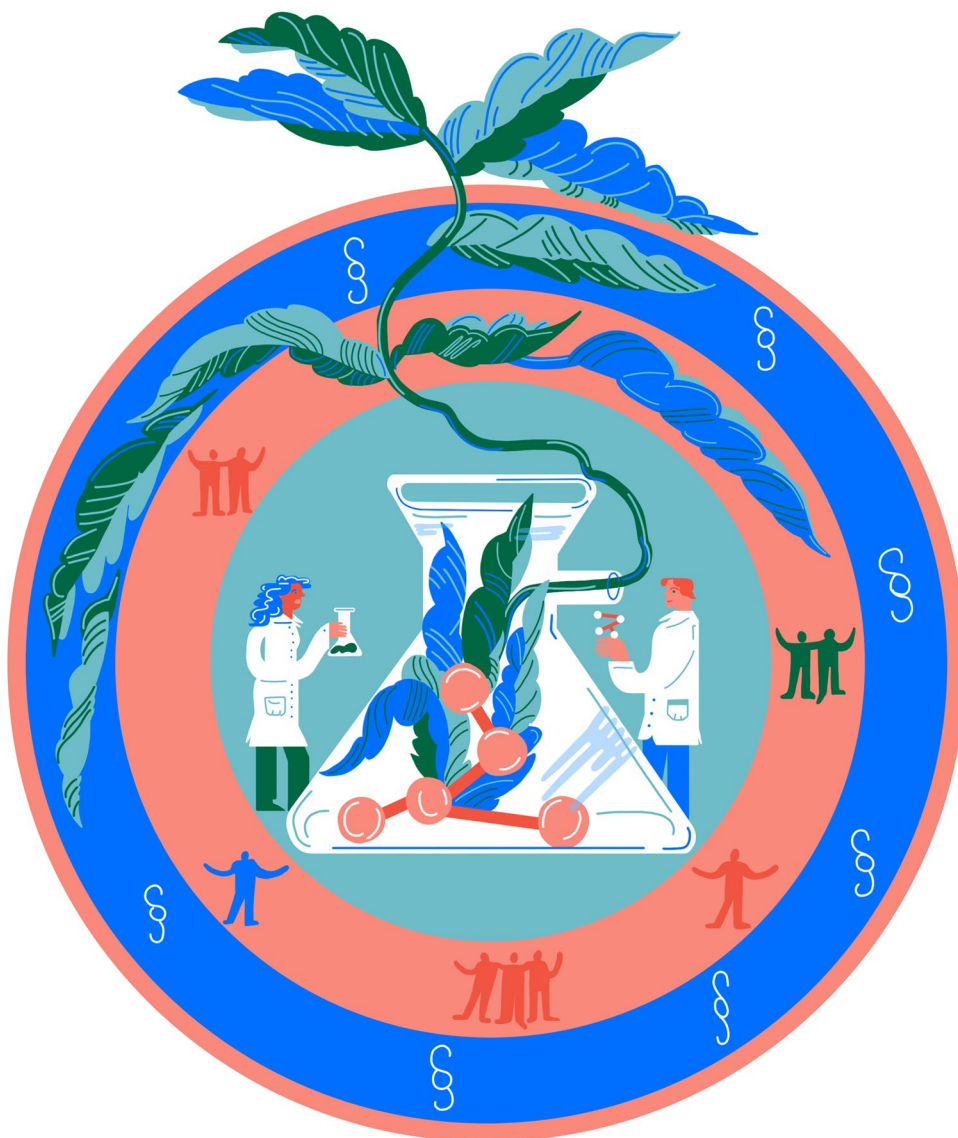
the supply chain (production and waste), thus reshaping the design and processes (the ways materials move around the system) of the production system (Fig. 5).

### What are the barriers that the interventions face in creating transformative change?

While all of the studied interventions target multiple and deep leverage points to create systems change, they all face challenges that limit the extent to which they achieve their goals. Across the interventions, participants in the case studies report that a lack of support and capacity available to the interventions limited their ability to affect meaningful change. Lack of capacity can be related to physical resources, including a lack of investment into research and development of benign chemicals (sustainable chemistry case), and a lack of financial resources to buy sustainably produced materials or access infrastructure and personnel (sustainable ventures case). Indeed, a lack of personnel and time to cover the range of sustainability topics and work to be done is an issue also in the individual change agents case. Such a lack of capacity places a reliance on the motivations and energies of individuals to create change. In the case of the textiles partnership, the networking and collaboration between representatives in the initiative and also between the different governance mechanisms relies on precisely these capacities and interests of individual stakeholders and is therefore essential. The sector already has many governance mechanisms, and engaging across these limits the capacity of stakeholder to actively engage in the partnership. The empathy, competence, agency, and resilience of individuals are key in both the individual change agents and the sustainable ventures cases. These individuals were key to driving forward changes within the support of family and friends (sustainable ventures).

Some of the barriers encountered by the studied case interventions highlighted the differences between the paradigms and worldviews represented by the intervention, and those of the system that they are trying to change. In the case of individual change agents, progress towards sustainability was hampered by misunderstandings between cultures and worldviews about how the industry functions, what its purpose is, and how work should be performed. The individual change agents represent a different way of doing business that clashes with the approaches institutionalised and reflected in the systems they are working to change. Similarly, in the multi-stakeholder initiative (textile partnership case), the need to create meaningful opportunities for mutual learning is at odds with a dominant culture of creating quick outcomes and decisions. Such pressure has led to the initiative itself closing down spaces for meaningful co-creation and learning between members in the pursuit of efficient decision-making. Moreover, as social media is

**Fig. 5** Systems onion for sustainable chemistry. The changes originate within the production system, but have implications that spread (like the shoots of a plant) into consumption, policy and regulation, and indeed into the broader ecosystems and environment that such industrial activities are embedded within



embedded in a hyper-consumerist paradigm, entrepreneurs in the sustainable ventures cases have been attracted to the idea of increasing consumption, thus undermining their own sustainability intentions.

Intertwined with the barrier of different worldviews is the barrier of the structures that perpetuate differences, or hinder the spread of other mindsets. For example, the individual change agents often lack opportunities to exchange amongst each other in safe spaces. This means that they cannot share and collaborate and have to act in isolation within ‘unsafe’ environments. They are further limited in their actions, because they often remain inside departments and mainly work within the too-small sustainability teams. They cannot easily reach other parts of the company, let alone reach beyond the companies they are operating within, and so cannot engage with the core business of the company. Whether or not individual change

agents could successfully overcome these barriers depends on how they were able to merge sustainability topics with core business. In some cases, individual change agents had to work with employees from other departments who were often acting towards different, often economic, goals. This represented an ‘othering’ of sustainability, rather than a mainstreaming through core operations, and limited opportunities for sustainability changes across the company. In other cases, individual change agents were successful in mainstreaming by moving beyond organisational boundaries and thereby creating greater leverage. In the textiles partnership case, structures of private regulation represent a barrier that perpetuates unsustainable behaviour. Multi-stakeholder initiatives rely on broader voluntary policies and agreements, whereas strict laws could instead foster sustainable production and consumption beyond national borders. Scaling up production operations

of the sustainable ventures would require massive financial investment or at least governmental financial incentives. And while the physical fashion market structure in Mexico renders a high cost for entrepreneurs, the virtual structure provides low cost and accessible reach to large portions of the population. In the sustainable chemistry case, the structures that created barriers were infrastructure, rather than organisational. The production infrastructure is designed for conventional processes in the textiles industry, consuming large amounts of energy and water, and creating a physical barrier to more sustainable practices.

### Which systems need to be targeted to remove these barriers?

The barriers directly experienced across our studied interventions all originate in system layers that are beyond the boundaries of the system that the interventions seek to change; broader system layers constrain the transformative potential of the interventions. Issues of capacity and internal structures experienced by our cases are shaped by the policy and regulation systems that each of the studied interventions and focal systems are embedded within. In particular, despite the difference in the policy systems that influence each of the cases, across all of them there is a lack of formal policy and legislative frameworks that would mandate the work of the studied interventions. Such lack of legislation can create barriers around making resources available to the interventions. For example, in the sustainable ventures case, there are no government incentives to support incoming entrepreneurs, as all the attention has been centred on the USMCA (USA–Mexico–Canada Trade Agreement) and other industries such as the automotive industry. In the sustainable chemistry case, the lack of R&D funding is related to a lack of legislation to mandate the need for alternatives. Indeed, a lack of clear international regulation across sectors creates incoherence; some chemicals are regulated by one directive when used for a specific purpose (e.g. substances used for the purpose of pest control under Regulation (EU) 528/2012 concerning the availability on the market and use of biocidal products), but can still be applied in other sectors for different purposes without falling under the same regulation.

Beyond driving the lack of capacity and resources, the lack of legislation in policy and regulation systems also drives the ‘othering’ of the studied interventions; it keeps them structurally separate from the systems they seek to change. For example, increased sustainability regulation and laws would help individual change agents by providing them with a greater mandate to create change, clearly shown now by the latest German and EU regulation such as the supply chain law, the Corporate Sustainability Reporting Directive (CSRD), etc. In the textiles partnership case, participants report that they have done all they can within the policy frameworks provided, and

that regulations need to change to mandate more meaningful sustainability actions. In particular, the voluntary nature of the textiles partnership case means that 50% of the German textile market does not participate, and of those that do, few are fully active in driving change. Furthermore, a lack of overarching, international framework means that there is an increasing number of (mostly private) governance mechanisms, with variable structures, processes and content, which compete for the time and energy of the actors involved. Thus, there is a role for policy and regulation to harness the transformative potential of the studied interventions, particularly by ensuring they are not crowded out to other issues. This role is currently absent.

Such an absence can be traced into economic systems, which encompass the intervention systems onions, and ensure there is little logic or need for the kinds of policies and regulations that would support the transformative potential of the studied interventions. For example, the structural barriers experienced by individual change agents happen because the interest of companies is often to focus on and increase economic performance and this outweighs the interest to achieve sustainability goals. In this perspective, sustainability is fine as long as it is within existing production and consumption logic and does not challenge the market logic of high-consumption or production-based business models (e.g. sustainable chemistry). Furthermore, the global textile sector is often highly competitive, which pushes margins and leaves fewer opportunities for individual change agents to negotiate for increased social and environmental standards that would further put pressure on prices. NAFTA is one example of how strategies are delineated to compete against the fibres and textile products from the Asian Market (Robinson 2010; Frederick and Gereffi 2011). In addition, the persistence and growth of fast fashion represents a tangible manifestation of this growth-based paradigm; consumers are mostly not interested in more expensive, truly sustainable products and can access less sustainable alternatives cheaply (sustainable ventures, individual change agents). In the case of sustainable ventures, entrepreneurs compete directly against retailers of discarded clothes from the USA. In this way, there is competition for consumers between the sustainable ventures and the cheaper alternatives offered by the existing production system.

In our case study interventions and beyond, the broader economic systems that the interventions (and their systems ‘onions’) are nested within severely limit their transformative potential, and it is these systems that need to be targeted for transformative change. This limitation is shown by even the most positive news in the sector being delivered according to a consumption logic and not a sustainability logic. Across all cases, participants in the research explained that there was an increase of sustainability and climate change awareness in the general public. This shift exerts pressure on companies to mainstream sustainability and is changing the openness of

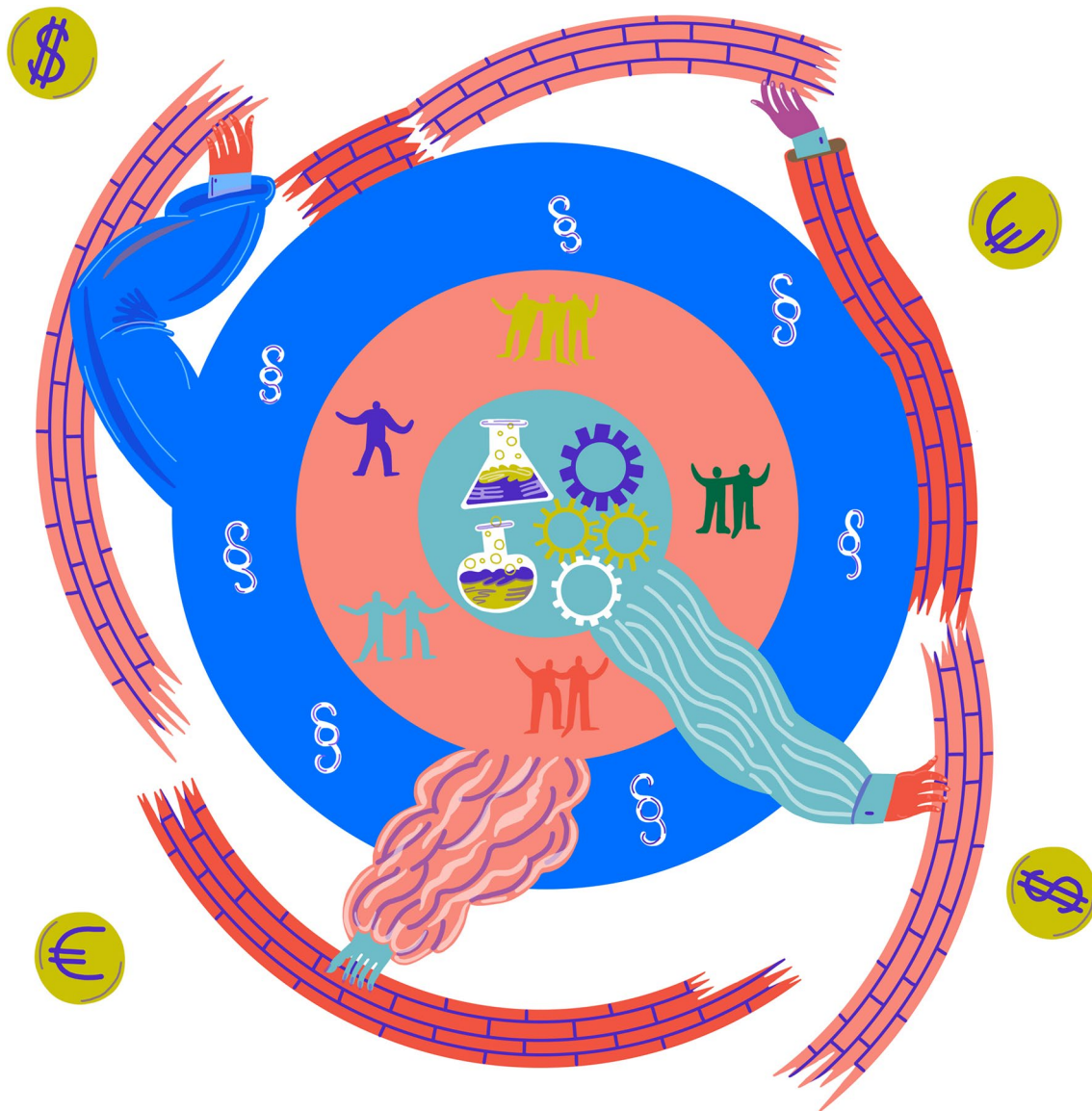
top management to impulses from outside (individual change agents). Further, it is creating a global niche for sustainable fashion, combined with social media and e-commerce, which is making it easier for entrepreneurs to show their innovations and interact with their end users (sustainable ventures). Further, the emerging EU's New Green Deal legislation is starting to provide legislative conditions that should change the intervention spaces for our cases. For example, the principle of Safe and Sustainable by Design has been integrated into the Chemicals Strategy for Sustainability within the European Green Deal. The industrial strategy also includes focus on the textiles sector, and on integrating circular economy narratives. However, these emerging seeds of hope remain within the logic of consumption and decoupling environmental impacts from economic growth. A shift in consumer awareness is towards buying differently, not necessarily less, and the enactment of this circular economy narrative is tending much more towards recycling, rather than reducing consumption and waste. While the details of all systems layers vary between the studied intervention, in all, the economic system layer provides a paradigm that is then carried into, and embedded within, the systems nested within this economic system, providing limits to the extent to which they can change (Table 3).

## Discussion: places to intervene for textile transformations

Our integrative research across four sustainability interventions in the textiles sector demonstrates how interventions are shaped and limited by multiple, nested systems layers, thus linking local interventions to bigger, global issues (cf. Salomaa and Juhola 2021). The interventions themselves all sought to intervene in deep leverage points in the layer of the textiles system that they targeted for change, their focal system. However, they faced many barriers to do so, and we can trace these barriers to the system layers that the interventions are nested within. What each system layer looks like for each of our interventions is of course different; they are context specific. However, as we traced the barriers towards the outer systems layers, there were shared systems properties that constrained all of the layers within. In particular, these relate to the high-throughput, high-consumption paradigms that are embodied by the economic systems and enacted through the policy and regulation layers. Across all of our examples, these shared paradigms of the economic systems ensure that the policy and regulation layers provide policy that supports economic growth and high levels of consumption of textiles products. In turn, the policy and regulation layers, therefore, do not provide the mandate or structures to support the studied sustainability interventions or mainstream them into the core purpose of the production and consumption layers. In response, the production

**Table 3** Summary of the barriers of transformation across the four cases, potential pathways to overcome the barriers, and the main systems that need to be addressed to move closer towards a sustainability transformation

Barriers of transformation across the cases	Paths to overcome these barriers	Main systems that should be addressed to move closer towards transformation
Lack of support and capacity (resources, time, financial capabilities, investments, research and development, infrastructure, personnel)	Motivations and energies, empathy, competence, agency, and resilience of individuals	In all cases, broader system layers limit the transformative potential of interventions that are embedded in and address the inner layers of the textile system. The policy and regulatory system must therefore be addressed, and ultimately the economic system that influences the deeper system layers and embeds paradigms and worldviews
Clash between traditional (economic) paradigms and (more sustainable) worldviews of the interventions	Overlap between corporate economic/industry/policy interests and sustainability goals	
Structural elements of governance, industry, or businesses that hinder collaboration in safe enough environments for broader mindset shifts	Informal initiatives or pilot projects	



**Fig. 6** The economic system needs to change to allow space for the systems nested within it to transform. The paradigm provided by the economic logic of high consumption is a barrier, or wall, to trans-

formative change for our intervention cases. Change can come from the other systems pushing against it and providing pressure to change, but must also come from within the economic system itself

and consumption layers are structured in a way that closes down, or fails to provide, spaces to ensure the interventions can challenge these dominant systems structures and paradigms. These inner systems layers are the local, contextualised enactment of these globalised economic paradigms. To create transformation, it is the deepest leverage points in these broad, overarching systems that must be targeted (Fig. 6).

Our findings provide further support to growing calls for paradigm change within global economic systems by tracing how these paradigms constrain bottom-up sustainability initiatives. Arguments from the proponents of post-capitalism and degrowth, and well-being-based economies, look

towards the growth-based economy as the root cause driving unsustainability across sectors and locations, pointing to high levels of consumption as driving unsustainability (e.g. Kallis 2019; Newell et al. 2021). Feola et al. (2021) argue that existing economic systems need deconstructing. Our findings agree on the need for such deconstruction because our case study interventions can only make changes within constraints provided by dominant economic paradigms and enforced by policy and regulation systems. By engaging with deep leverage points within the production and consumption systems, our cases try to push out and change these broad system layers from within. However, they are not able to



engage with the deep leverage points within the economic systems that provide most constraint.

Of course, these arguments neglect considerations of time, scaling up and out (Moore et al. 2014) and how shifts within focal systems can create knock-on impacts (e.g. spill-overs, tipping points) (Liu et al. 2015), or shifts in organisational cultures (Russell and McIntosh 2011). Arguably, these interventions could push against the outer layers of the system onion from within. This would be a similar mechanism to systems entrepreneurs working against dominant system structures to create change that better aligns with their own values (Kapoor et al. 2007). It would also be in line with the idea of increasing the numbers of individuals within the system adopting a particular behaviour (e.g. shallow scaling, Newell et al. 2021), and thus triggering sudden systems change. This is the concept of tipping points in systems change (see e.g. Bentley et al. 2014). Similarly, bundling of multiple interventions over time can create a critical mass that pushes outwards, creating pressure on the outer layers of the onion (see e.g. Fletcher 2009). In this way, it is important that our studied interventions do indeed engage with the deepest leverage points of *paradigms* in these inner systems (or layers). Shifting the *paradigms* of these inner nested systems creates more pressure outwards, as was shown in all of our cases that were looking for greater policy and regulation. Indeed, it is a plausible argument that intervening in our target systems will, over time, create more fundamental transformation across the textiles sector.

We suggest here then that a promising line of future enquiry would be to explore these pathways of change in a longitudinal study, exploring how interventions are scaled up and down through connected systems layers. In this way, we therefore challenge researchers to think beyond questions of scaling up initiatives and behaviours (cf. Moore et al. 2015; Lam et al. 2021; Newell et al. 2021) and urge consideration also of scaling through the systems onion. This is similar to Newell et al.'s (2021) scaling deep idea, of systems changes that unlock the kinds of behaviour changes that are needed in individuals. However, it goes further by demonstrating the role of scaling changes in systems properties, and asking how, e.g. *paradigm* changes at inner system scales can be spread to those at overarching outer system scales. Working from the opposite end, it could also support exploring how changes at the outer system scales unlock transformations in the systems nested within them. We therefore suggest that this process of linking interventions and their implementation barriers to nested systems is useful for questioning our assumptions about the pathways of systems change, and for identifying which interventions could usefully be targeted at which leverage point and in which systems (cf. Leventon et al. 2021). We should acknowledge that interventions at deep leverage points in systems may in fact be fairly shallow when we recognise that these systems are nested within

broader systems that shape and constrain them. Understanding pathways to target fundamental change in organisational culture at the central system level (e.g. production, consumption) is of utmost importance (Russell and McIntosh 2011). But in addition to creating changes in focal systems, we must be seeking to create changes in these broader systems to unlock the changes made by individuals and smaller systems. This suggests that when we talk about systems change, we can be more specific about what system we mean, and what it looks like, and therefore who needs to make what changes. Previous analysis has focussed on those with highest emissions as being those that can unlock change (e.g. Nielsen et al. 2021; Newell et al. 2021; Whitmarsh et al. 2021). We acknowledge this as an important component in systems change, and indeed from a justice perspective, behaviour change here must absolutely happen. We add that the most influential people to target for sustainability transformation are those with most power to change the policy and regulation systems, and economic *paradigms* that we sit within. The extent to which these may be the same people points us towards understanding the processes of power and political economy (cf. Stoddard et al. 2021).

## Conclusions

In this paper, we have demonstrated four case study interventions for sustainability that target fundamental changes within the production and consumption systems of the textiles sector (textiles partnership, individual change agents, sustainable ventures, and sustainable chemistry). However, they are limited in their transformative potential by the broader system layers of policy and regulation, and the economy. Using a leverage points framework, we explored how these interventions sought to change *paradigms*, *design*, *processes* and *materials* within these systems. All sought to enact changes by engaging with the deepest leverage points, but all were hindered in their ability to achieve their own goals and sustainability within the sector. Using an integrative and reflexive approach, we developed an onion model of the complex nested systems that comprise the textiles sector. In doing so, we found that the studied interventions were limited by the systems of policy and regulation, and economy. In particular, the consumption-focussed economic *paradigm* constrained the opportunities for our case interventions to act, and meant that they were ‘othered’ to the core consumption-focussed business of the textiles sector. Further, there is a lack of policy and regulation in the sector to control, incentivise or support the activities of our case interventions. We therefore find that relying on bottom-up interventions is unlikely to deliver rapid, fundamental transformation to the textiles sector unless there is also fundamental transformation in the systems it is embedded within.

Transformation in both policy and regulation, and economic systems has the advantage that multiple systems are nested within them, so change here creates change across multiple systems and sectors (e.g. food, energy). The risk of not intervening in these broad systems is that they are in turn (and whether they like it or not) embedded within our planetary, ecological system; when they reach the edges of this planetary system, and push outwards too far, the collapse will trigger far reaching, un-steered changes within all systems within it.

Although we have pointed to the limits of our interventions in delivering sustainability transformations, we also wish to leave the reader and our study interventions with hope. The interventions themselves, by engaging with the deepest leverage points in these inner systems, are pushing out against the boundaries of the system they are embedded within. We suggest that there is potential for these interventions to create critical mass, knock-on impacts or tipping points that spill over into the broader layers of the system. To understand these processes, we outline the potential for research that follows pathways of change, particularly in scaling interventions through system layers. Our reflexive approach of questioning which intervention, in which system, and how systems are connected, is particularly useful for exploring such pathways, though a study would need to be longitudinal to trace the process further. In addition, we highlight that this onion modelling process for systems is also useful for questioning who needs to change what, and in which system, focussing our attention towards engaging with actors in policy and regulation and the economy to shift the *paradigms* and *designs* that they reflect. By thinking in connected systems, and targeting deep leverage points across all connected systems, we can create much greater opportunities for our interventions to deliver transformations.

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