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Article

Design for Sustainability Transitions: Origins, Attitudes and Future Directions

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Abstract: Sustainability transitions have formed a vast body of literature on theory and practice of transforming socio-technical systems to achieve sustainability over the past few decades. Lately, a new area has been emerging in the design for the sustainability field, where sustainability transitions theories are integrated with design theory, education and practice. This emerging area is referred to as design for sustainability transitions or transition design. In order to build an understanding of the emergence and growth of this area, this article presents an overview of origins, development and current status of design for sustainability transitions drawing on key contributions. We also provide a comparative analysis of these key contributions in regards to their theoretical underpinnings, definitions of sustainability, conceptual framings for the roles of design(ers) and premises of methods and applications.

Keywords: sustainable design; sustainability transitions; design research; design theory; design practice; transition design; design for sustainability transitions

1. Introduction

Most of human society is currently going through quite challenging times due to our current global socio-ecological problems surfacing unprecedented complexities and challenges. The major challenges many human civilisations have faced historically—such as wars, epidemics and natural disasters—had limited spatial or temporal scope, although they had been devastating for the impacted communities. However, the challenges being faced currently have significance beyond the lifetime of the present and near-future generations as well as several adverse implications on non-human elements of ecosystems. For example, the impacts of climate change are expected to continue disturbing and destabilising many oceanic ecosystems for a period longer than the existence of settled societies [1]. Research shows that a temperature rise to 1.5–2 °C compared to pre-industrial levels, can have risks associated with climate change [2–4]. However, we approach rapidly the critical levels, as the targets for emission reduction are still not being met.

Although arguably the most urgent, climate change is not the only significant challenge the being currently faced. The “Planetary Boundaries” framework delineates a *safe operating space* for humanity by setting out the precautionary boundaries for nine crucial processes of human-driven environmental change [5,6]. As reported by this study, boundaries for biosphere integrity and biochemical flows have been extremely breached by the safety boundaries and they pose high risk. Climate change and land-system change boundaries have been breached posing growing risk. Novel entities and atmospheric aerosol loading boundaries are yet to be quantified and the levels of breach to these boundaries are yet to be measured. Only three of the nine boundaries, freshwater use, ocean acidification and stratospheric ozone depletion, are within the designated safety boundaries. Once these processes exceed the critical limits that boundaries refer to, we might face accelerated and

large-scale alterations in the functioning of Earth systems, which might expose many societies and economies worldwide to significant risks.

Beyond challenges related to Earth systems functioning, some are also facing major social challenges. Complementing the Planetary Boundaries framework, Raworth [7] developed an integrated concept of social foundations. She proposed a *safe and just operating space* that lies between the environmental limits and social foundations, which are identified as the social foundations for justice. These foundations include clean water, food, energy, health care, education, social equity, gender equality, income and work, resilience and voice. Through illustrative indicators, she demonstrated how many of us presently fail to deliver a just distribution of these social foundations across different geographical contexts.

These and several other studies acknowledge that the socio-technical systems currently supporting our society and meeting our needs require radical and transformative restructuring [8]. Such large-scale transformations demand urgent action from all sectors of the society, even though framing the required pace and direction of these transformations concretely and with high certainty is difficult—as these transformations deal with wicked problems, and there is a lack of consensus around desired solution states. Aligned with this need for comprehensive transformative change, a new agenda of research and practice, system innovations and transitions to sustainability, or shortly, sustainability transitions [9,10], has grown out of science and technology studies field since early 1990s.

Sustainability transitions necessitate shifts in our institutional, organizational, socio-cultural establishments in addition to technological configurations [10]; in other words, they require systemic changes at societal level. Moreover, transitions are creative, political and technical design challenges. Transitions demand envisioning alternative systems, appraising system processes and concepts as well as facilitating participatory-deliberative processes to move the collective and political nature of transitions forward [11]. Ceschin and Gaziulusoy [12] have investigated the evolution of design for sustainability (DfS) field from its initial conceptions to contemporary apprehensions. Their analysis signifies that the subject matter of the field has expanded both in terms of its scope and its timeframe. Besides, the field has grown out of its palliative position into one that is strategic as the complexity of problem and solution contexts gained further awareness and expression over the years. Ceschin and Gaziulusoy [12] identified an emergent research and practice area evolving in the DfS field, which has been partially influenced by system innovations and transitions theories and which aim to respond to the contemporary urgencies for substantial action and systemic change. This emerging DfS area resides at the socio-technical innovation level and incorporates spatio-social, product-service system, product and material innovations.

This article traces the origins of this emerging area and presents the key theoretical and methodological contributions, discusses its current state-of-the-art and provides pointers for future research and practice. In this article this emerging area is referred to as design for sustainability transitions (DfST), however, this emerging area is also referred to as transition design.

2. Origins of and Attitudes in Design for Sustainability Transitions: A Historical and Comparative Overview

2.1. Methodology

It is difficult to pinpoint a precise beginning for development of thought in a research area as evolution proceeds in continuum. The finest practices for investigating the origins of a phenomena take tangible evidences—traces, remains—left behind into consideration to distinguish the initial phases of evolution. When the case at hand is evolution of thought, evidence materialises in the form of text through which thought pieces become coherent wholes. In this article, we scrutinize the origins and advancement of this emerging DfS area that links sustainability transitions and design by focusing on the key work that integrated these two streams of research. The key work for analysis has been collected through two fundamental and interrelated parts. The first part constitutes an iterative, expert-led process of developing a list of key publications. The first version of this list has

been prepared by the first author based on her in-depth knowledge of the integrative work on topics of product development and system innovations as well as on urban sustainability transitions as the first author's doctoral and post-doctoral research (2006–2013) as well as professorship (2013-ongoing) research foci covered these. Through this list a set of experts were identified who contributed into the development of this emerging area. The list has been circulated among these experts requesting for contributions of any key references missing.

In order to expand this list and account for the potential key work that may have been considered peripheral by or left outside of the awareness scope of the first author and the selected expert group, the second author followed a systematic search in the second part. This search was conducted in Scopus which indexes several major relevant academic publishers (including Elsevier, Taylor and Francis, Inderscience, Sage and Wiley-Blackwell) using Boolean keyword search term: "design" AND "system innovations" AND/OR "transitions" AND/OR "socio-technical innovation" in the title, abstract and keywords. As some significant design journals are not indexed by the Scopus (for example Design Issues and Strategic Design Journal), a search was also conducted in googlescholar, DOAJ (Directory of Open Access Journals) and using the search function directly in the websites of these design journals. The search results were filtered for disambiguation and the list of key references was finalised. Table 1 lists down the final set of selected publications that has been analysed.

Table 1. List of publications used in constructing a history of integration of design and sustainability transitions.

Resource (in Chronological Order)	Geographical Origin	Title of the Publication	Publication Type
Brezet, 1997 [13]	The Netherlands	Dynamics in ecodesign practice	Journal article
Young et al., 2001 [14]	The UK; The Netherlands; Hungary	Exploring sustainable futures through ‘Design Orienting Scenarios’—The case of shopping, cooking and eating	Journal article
Cipolla and Peruccio, 2008 [15]	Italy; Brazil	Proceedings of the Changing the Change: Design Visions, Proposals and Tools, An international conference on the role and potential of design research in the transition towards sustainability	Edited conference proceedings
Ryan, 2008a [16]	Australia	Climate Change and Ecodesign	Journal article
Manzini, 2009 [17]	Italy	New design knowledge	Journal article
Dewberry and Johnson, 2010 [18]	The UK	Design interventions, prediction and science in the sustainable transition of large, complex systems	Conference article
Gaziulusoy, 2010 [19]	New Zealand	System Innovation for Sustainability: A Scenario Method and a Workshop Process for Product Development Teams	PhD thesis
Joore, 2010 [20]	The Netherlands	New to Improve, The Mutual Influence between New Products and Societal Change Processes	PhD thesis
Kossoff, 2011 [21]	The UK	Holism and the Reconstitution of Everyday Life: a Framework for Transition to a Sustainable Society.	PhD thesis
Ceschin, 2012, [22]	Italy	The introduction and scaling up of sustainable Product-Service Systems: A new role for strategic design for sustainability	PhD thesis
Gaziulusoy, Boyle and McDowall, 2013 [23]	New Zealand	System innovation for sustainability: a systemic double-flow scenario method for companies	Journal article
Ryan, 2013 [8]	Australia	Critical Agendas: Designing for Sustainability from Products to Systems	Book chapter
Ceschin, 2014a [24]	Italy	The societal embedding of sustainable product-service systems. Looking for synergies between strategic design and transition studies	Book chapter
Ceschin, 2014b [25]	The UK	How the Design of Socio-technical Experiments Can Enable Radical Changes for Sustainability	Journal article
Heiskanen et al., 2014 [26]	Finland	User involvement and radical innovation: The case of heat pumps in Finland	Book chapter
Gaziulusoy, 2015 [27]	Australia	A critical review of approaches available for design and innovation teams through the perspective of sustainability science and system innovation theories	Journal article
Gaziulusoy and Brezet, 2015 [28]	Australia; The Netherlands	Design for System Innovations and Transitions: A Conceptual Framework Integrating Insights from Sustainability Science and Theories of System Innovations and Transitions	Journal article
Irwin, 2015a [29]	USA	Transition Design: A Proposal for a New Area of Design Practice, Study, and Research	Journal article
Irwin, 2015b [30]	USA	Transition Design: A new area of design research, practice and study that proposes design-led societal transition toward more sustainable futures	Monograph
Irwin, Tonkinwise and Kossoff, 2015 [31]	USA	Transition Design: An Educational Framework for Advancing the Study and Design of Sustainable Transitions.	Conference article

Table 1. Cont.

Resource (in Chronological Order)	Geographical Origin	Title of the Publication	Publication Type
Joore and Brezet, 2015 [32]	The Netherlands	A Multilevel Design Model: the mutual relationship between product-service system development and societal change processes	Journal article
Kossoff, Irwin and Willis, 2015 [33]	USA; Egypt	Transition Design	Special issue editorial *
Kossoff, Tonkinwise and Irwin, 2015 [34]	USA	Transition Design: The Importance of Everyday Life and Lifestyles as a Leverage Point for Sustainability Transitions	Conference article
Ceschin and Gaziulusoy, 2016 [12]	The UK; Australia	Evolution of design for sustainability: From product design to design for system innovations and transitions	Journal article
Gaziulusoy and Ryan, 2017a [11]	Australia	Roles of design in sustainability transitions projects: A case study of Visions and Pathways 2040 project from Australia	Journal article
Gaziulusoy and Ryan, 2017b [35]	Australia	Shifting Conversations for Sustainability Transitions Using Participatory Design Visioning	Journal article
Gaziulusoy and Ryan, 2017c [36]	Australia	Imagining Transitions: Designing a Visioning Process for Systemic Urban Sustainability Futures	Conference article
Hyysalo, Johnson and Juntunen, 2017 [37]	Finland	The diffusion of consumer innovation in sustainable energy technologies	Journal article
Mok and Hyysalo, 2018 [38]	Finland	Designing for energy transition through Value Sensitive Design	Journal article
Erdogan Öztekin and Gaziulusoy, 2019 [39]	Finland	Designing Transitions Bottom-up: The agency of design in formation and proliferation of niche practices	Conference article
Hyysalo et al., 2019 [40]	Finland	Codesign for transitions governance: a mid-range pathway creation toolset for accelerating sociotechnical change	Journal article

* This special issue has 10 articles which are not separately listed here.

2.2. The Origins and Current Status of Design for Sustainability Transitions

The set of publications listed in Table 1 is indicative of the emergence and ongoing development of DfST. Within the scope of this article, it would be impractical to discuss each publication in this list in detail. Nonetheless, we compile the “key points” which could be considered as the unique contributions of these publications in the development of thought bridging design and sustainability transitions.

Brezet’s Dynamics in Ecodesign Practice [13] is the oldest resource that can be traced in literature that considers socio-technical system innovations in the context of DfS. It provides evidence that the integration and therefore the emergence of DfST started as early as in late 1990s. In this journal article, he delineates four types of ecodesign innovations. In correspondence with their increasing potential for environmental improvements, these types respectively are product improvement, product redesign, function innovation and system innovation. Brezet [13] conceptualizes system innovations as changes in infrastructures and/or organisations required due the emergence of new products and services. This conceptualization resembles to an early, although a premature description of system innovations. System innovations is a core term of sustainability transitions literature referring to one socio-technical system transitioning into another [9]. Brezet [13] refers in his article to The Dutch National Inter-Ministerial Programme for Sustainable Technology Development which took place between 1993 and 2001 [41]. This programme played a pioneering role in the establishment of system innovations and transitions research. As Brezet stated [13], scenarios and back-casting methods were used in this programme to “develop a vision for sustainable function fulfilment by systems in the year 2040” (p. 23).

One other key influence has been Changing the Change Conference—the first academic conference discussing design and sustainability transitions dating to 2008 [15]. The conference can be considered as a significant landmark in the emergence of DfST with a total of 138 papers presented. Although only a few of the contributions in this conference specifically put emphasis on structural and systemic changes as discussed in system innovations and sustainability transitions theories, all contributions focused on social learning and change through design. The conference addressed the requirements for lifestyles changes and for reconfiguring innovative solutions on how to meet societal needs. Consequently, a consensus began to be formed around the idea that sustainability should be taken as a meta-objective leading all design research activity. Although these 138 papers are not individually listed in Table 1, examples indicative of emergence of DfST include: Ryan [42] who argued for paradigm change by means of design-visioning; Vezzoli, Ceschin and Kemp [43] who established links between design and transition management; and Boehnert [44] who discussed what designers could learn from the back-then young yet growing Transition Towns movement.

Between 2010 and 2012, the first PhDs that established a link between design and sustainability transitions were completed. Gaziulusoy’s work was situated at the intersection of sustainability science, system innovations and transitions theories and design theory [19]. Joore, on the other hand, situated his work tightly within industrial design engineering, exploring the mutual influence of new products and societal change processes [20]. Ceschin, situated his work within the maturing research area of sustainable product-service systems (SPSS) and argued SPSS can be considered as system innovations as they require changes in user practices, organisational structures, regulatory frameworks and culture [22]. These three PhDs were similar in the sense that they all referred to and used multi-level perspective of system innovations [9] and other models and theories of system innovations and transitions literature in constructing their theoretical/conceptual frameworks. They also focused on product (understood in a broad sense) development and each differently demonstrated how the work of designers is or can be linked to societal change processes for sustainability.

On the other hand, Kossoff [21] followed a very different path. He argued that it is the everyday life that needs to be sustainable. He referred to contexts within which most pre-industrial societies satisfied their needs as *domains of everyday life* and argued that the relative sustainability of those societies stemmed from their control over satisfaction of needs (rather than top-down control of needs satisfaction in modern societies) in holistic ways. His understanding of design—particularly transition

design—is that it should be an activity of everyone and should constitute facilitating emergence of nested domains of everyday life and make them *whole*.

Building on ideas of Kossoff [21], Irwin [29] published an article presenting a transition design framework for design education, research and practice. This article has coined the term transition design and popularised it within the broader community of design academics and practitioners. She situated transition design as an emerging area at the end of a design continuum, following service design and design for social innovation, thereby, making links between transition design and other new areas of DfS. In 2012, Carnegie Mellon University, School of Design have started to implement curriculum formulated using transition design as an umbrella framework across all levels of design education [45]. In 2015, the first journal Special Issue on transition design was published [33].

The other contributions made by the key work listed in Table 1 include a first, exploratory study on the roles of design in transition processes [11], an inquiry into design as a facilitator of learning in transitions [39], explicit use of particular design approaches in transition projects [38], investigations of evidences of user involvement in the design and diffusion of new technologies in transition projects [26] and methodological advancement of transition pathways development by redesigning transition arenas and using a co-design approach for mid-range transition planning [40].

2.3. Attitudes in Design for Sustainability Transitions

This section presents the current diversity of *attitudes* in DfST by grouping the work of authors who have contributed into DfST literature in a systematic and ongoing manner. We comparatively analyse these contributions in regards to their theoretical foundations, frames and measures of sustainability, framings of the roles and agencies of design, and their proposed methodological frameworks and methods for DfST practice.

2.3.1. Theoretical Foundations

Table 2 shows the main theoretical groundings the contributions in DfST are built upon.

Table 2. Theoretical foundations of selected work.

Contributions	Theoretical Foundations
Gaziulusoy [19]; Gaziulusoy, Boyle and McDowall, [23]; Gaziulusoy and Brezet [28]	Sustainability science; complex adaptive systems; system innovations and socio-technical transitions theories; futures studies (scenarios); product development; business strategy
Joore [20]; Joore and Brezet [32]	Industrial design; systems engineering; sustainable product development; system innovations and socio-technical transitions theories
Ceschin [22,24,25]	Product-service systems; strategic design; system innovations and transitions theories; strategic niche management
Kossoff [21]; Kossoff, Tonkinwise and Irwin [34]; Irwin [29,30]; Irwin, Tonkinwise and Kossoff [31]	Chaos and complexity theory; Goethean science; holism; needs theory; everyday life discourse; indigenous knowledge; post-normal science; social psychology; social practice theory; alternative economies; socio-technical system innovations and transitions theories
Heiskanen et al. [26]; Hyysalo, Johnson and Juntunen [37]	User innovation in transitions

2.3.2. Framings and Measures of Sustainability

In parallel to the variety of theoretical foundations feeding into this emerging area, there is also a multiplicity of sustainability framings encountered across the key contributions into DfST. Gaziulusoy's work [19] (see also subsequent publications, [23,28]) essentially builds on the ideas of sustainability science, and it is particularly inspired by the theories of complex adaptive systems. According to her, sustainability is a systemic property therefore it needs to be addressed beyond the product, with references to the (socio-technical) system the product is part of. Sustainability is not an absolute

property; it can only be established relative to the nominal lifespan of the system to be sustained. Consequently, sustainability measurement is not possible in absolute form; instead it is possible only by comparing the nominal lifespan of the subject system category with the actual lifespan of the system in concern. Therefore, whether a system was sustainable or not can be evaluated with precision only *ex post facto*. Nevertheless, sustainable systems can be envisioned and enacted upon across relevant system levels and timeframes based on our current knowledge about their tipping points. In system innovations and transitions projects as well as in organizational strategies, Gaziulusoy [19] argues that the strong sustainability model needs to be adopted and this strong sustainability understanding needs to be integrated in strategies informing technology and product development.

Joore's [20] definition of sustainability derives from the work of Tukker and Tischner [46], which frames sustainability as a goal for diminishing negative environmental impact whilst enhancing social well-being as well as adding economic value. It is understandable that Joore [20] does not confront the challenge of dealing with elusiveness of sustainability as a research term as his primary aim is to investigate the role new products can play in societal level change, and it is only consequential that the context his work is embedded in deals with sustainability transitions. On the other hand, Ceschin [22], even though minimal, opens up a discussion about the fundamental themes of sustainability discourse such as growth, equity and limits. He argues that, especially in mature industrialised contexts, consumption and exploitation of environmental resources should be reduced at least by 90% and a fair distribution of resources should be targeted.

Kossoff [21] is critical of the mainstream academic discourse and research on sustainability for conserving the neoliberal status quo, and for not substantially questioning the overarching conventions upon which our society is currently established. According to him, sustainability needs to be addressed within the complexity of our current ecological, economic, social, but also cultural, existential and political problems. Kossoff [21] argues that everyday life becomes sustainable again across its all domains. Positioned against quantitative understandings of sustainability, he is in favor of building a qualitative understanding, where sustainability is defined as *wholes of everyday life*. He gives credits to participation, self-organization, emergence, intrinsic relatedness, multiplicity in unity, and meaningfulness in the everyday life as pointers of sustainability. The influence of Kossoff's work [21] is evident in the framings and discussions in following publications (see [29–31,34]) where sustainability is interpreted as a place-based property of globally networked communities, informed by visions of whole lifestyles which diffuse through everyday practices.

2.3.3. Agency and Roles of Design(ers) in Transition Processes

One of the shared main endeavours in establishing DfST has been the reflective inquiries into potential agencies and roles that design plays and can further play in transition processes.

Designers have significant roles in sustainability transitions in Gaziulusoy's framing, since they have decisive and creative agency in the creation of new products, services, and even meanings within new socio-technical systems [19]. Nonetheless, despite their significance, designers' agency is still limited in influencing change at societal level. One major reason of this limitation is that their work takes place in the operational timeframe of transitions. Designers are bounded by short-term requirements informed by company strategies. Gaziulusoy [19] argues that company strategy has an intermediary yet crucial role in translating long-term, societal-level visions of sustainability into concrete decisions and actions at design level in the short-term. Equally, company strategy has an intermediary role for design level to take part in societal-level vision-making. Similar in Joore's work, the role of design(ers) cross-cuts different system levels and varies in its scope, including undertaking tasks of normal product design, visualising and co-thinking visionary future solutions [20]. It can be observed that, by these formulations, Joore [20] and Gaziulusoy [19] both draw attention to the indirect agency of design(ers). Joore, understands the agency of designer to be high and direct at product development level but as the scope of the system get larger, the agency decreases and the role becomes indirect or diffused [20]. Ceschin [22] expands on the multiple roles designers can (and should) play in

sustainability transitions. These include designing socio-technical experiments, within which new sustainable product-service system concepts can be ideated and developed, and designing transition paths for embedding these sustainable product-service systems in the societal context.

Gaziulusoy [19], Joore [20] and Ceschin [22] portray designers who resemble the generic designer archetype yet who has relatively broader skills and knowledge base, and who embrace sustainability-oriented attitudes and values. It does not require a radical change in our current university programs to educate these designers. On the other hand, the designer portrayal Kossoff [21] draws requires radical reconsiderations in our understandings of design and design education. As he puts it, a transition designer—which everyone can become one—has the fundamental task of bringing into existence those domains of everyday life that are declined through modernity. While doing so, a transition designer would need to defend or restore the relationships between people, nature and artifacts at all levels of scale. For example, a transition designer is a multi-faceted, place-based activist who discusses, conceives and plans, for example, a compost heap at the household, a citizen assembly at the city or ecological education at the regional levels. Subsequent work of Irwin [29,30] and Irwin, Tonkinwise and Kossoff [31] puts emphasis on the qualities of transition designers rather than their specific roles. They outline the necessity for adopting a mindset and posture which embraces the philosophies for envisioning and bringing into existence place-based sustainable everyday lifestyles.

Heiskanen et al. [26] and Hyysalo et al. [37] have studied transitions with a particular focus on user innovation, thereby contributing into an understanding that the binary view on roles of designers versus non-designers is flawed and that, perhaps, the focus should be on the role and agency of design rather than of designers. On the other hand, Erdoğan Öztekin and Gaziulusoy [39] tackle the less designer-informed and the more group-driven design processes that are encountered in emergent and bottom-up transitions. Therefore while keeping a distance to institutionalised design, they build affinity with the understandings of design as a basic human activity and purposive action.

2.3.4. Methodological Frameworks and Methods for Design

The approaches towards DfST have different foci and thus different methodologies have been suggested. With multiple overlaps in between, scenario development for transitions and stakeholder engagement have been grouping around the endeavour for drawing strategic pathways for transitions [19,23,28,40] while pilot experiments and niche system implementations have been grouping around the endeavour for generating alternative systems [25,31,43,47].

Gaziulusoy [19] has developed an operational tool which enables design and innovation teams to align their day-to-day design decisions and strategic outlook with unfolding and upcoming sustainability transitions. This operational tool—a scenario method—integrates formerly disparate explorative and backcasting approaches together in order to causally bridge actual present decisions with future visions. Ceschin [22] also developed a very elaborate tool set for practicing designers. This tool set included tools to formalise PSS concept visions, tools to develop and formalise transition strategies, tools to manage the network of actors and tools to monitor and evaluate the transition process.

Irwin, Tonkinwise and Kossoff [31] have proposed a conceptual curricular framework for embedding DfST (transition design as they refer to the field) in design education. They argued that case studies should be an important constituent of the curriculum and that case study projects should (1) include a critique of existing conventions from a transition point of view and (2) offer a solution for transitions. The methodical framework they promote in the curricula is the visioning-backcasting approach which has been widely used in transitions projects since the early work of 1990s. It is expected that this group will build some empirical base opening the conceptual framework into testing and improvement and thereby contribute validated theoretical insights and new methodical tools into DfST in the coming years as their curriculum development endeavours mature towards fruition following completion of currently ongoing PhD projects.

Vezzoli et al. [43] propose a transition model for evolutionary co-design while they put sustainable (product-service) system innovations in focus. Their model introduces conceptualised phases, which

evolve in cyclical and iterative activities around stakeholder involvement, vision adaptation, design improvement and evaluation. The process they suggest starts with generating a PSS prototype, then continues with pilot project experimentation, which is later introduced as a system innovation niche and finally scaled-up.

Joore [47] draws a V-Cycle System Innovations model for successful implementation of product or service innovations depending on a case study. This model is a tool rather than a method, which facilitates clarifying the contemporary dependencies of stakeholders, and developing insights about stakeholders' expectations not only from the project but also from each other. However, even though it has been argued as cyclic, V-Cycle model seems to be an elaborated version of a linear process.

Hyysalo et al. [40] have introduced insights from collaborative design research to transition processes and developed a *mid-range pathway creation toolset* for accelerating sociotechnical change. This toolset equips diverse groups of front-runner actors with the means to envision and collaboratively construct pathways for accelerated systems change in a mid-range, 10–20-year timespan.

2.4. Reflections on Findings

Based on the analysis we present in former sections, the integration of design with sustainability transitions has its origins back in late 1990s. Back then, ecodesign was the dominant mode of thinking for considering design in the context of sustainability challenges. This view was predominantly focused on the resource challenges informed by production-consumption patterns and systems. We notice in the work of Young et al. [14] early endeavours of situating *the social* and *everyday life* at the core of DfS dealing with radical system changes. This expansion of scope is not surprising as, even in the early work of Brezet [13] integrating design and system innovations, there was acknowledgement that such large scale changes cannot be addressed solely at product development level but there is a need for infrastructural and organisational changes. This realisation also surfaces in the PhD works of Gaziulusoy [19], Joore [20] and Ceschin [22], in which they conceptualized product development as a systemically situated process in the broader context of societal changes. The multiplicity and geographical diversity of contributions to the Changing the Change Conference in 2008 also validates that even before these first PhDs were accomplished, design field had been cross-fertilised by sustainability transitions research. Late 2000s and early 2010s have seen a significant influence of system innovations and transitions theories [9,10,48] in DfS work. These theories were shedding light on how socio-technical changes happen and how they can be navigated. This, consequently, provided some foundations for building an understanding of how design researchers could start linking design theory and practice with sustainability transitions.

The three PhDs mentioned above [19,20,22], although fundamentally based on system innovations and transitions theories, generated a set of theoretical (and operational) frameworks with similarities but also differences. Kossoff [21], on the other hand, followed a different path and situated his work in philosophy, social ecology, and everyday life discourse without any reference to system innovations and transitions theories. All of the work analysed in this article are highly integrative, building on several disciplinary lineages and bodies of literature. Therefore, it is not easy to single out a body of literature as *the* foundational theory each contribution is based on. In addition to the multiplicity of theoretical foundations of each contribution, there are also overlaps between contributions. Some of the contributions are either based on or incrementally expand earlier contributions.

This requires some reflections on the disciplinary embedding of DfST. DfST has so far been studied with references to product design and innovation [19,20,22,28,32], business design strategy [19,23], strategic design [22,24], service design and innovation [14,29,32], design for social innovation [29], design of and in everyday life [21,26,37], urban transitions [11,35,36] and co-design [38,40]. This is aligned with the systemic focus of the field and perhaps also a result of its integrative nature. Therefore, DfST cannot be attributed to a single discipline of design in the traditional categorization of design disciplines which bounds design into disciplinary categorisations based on the output of design activity (e.g., product design, service design, fashion design). DfST can be relevant to any design activity which

aims to contribute into sustainability transitions. Following from Ceschin and Gaziulusoy [12], rather than into a discipline, we would like to suggest to situate DfST into the broad area of DfS.

Based on the key work listed in Table 1, observations about the geographical distribution of contributions can be made. The majority of the listed work are produced within the European context. This is unsurprising as system innovations and transitions field has been established and matured in the European context and the DfST field has been influenced substantially by this body of literature. However, Table 1 also includes key work from outside of Europe, for example from Australia, New Zealand and the USA. In our search we could not find key theoretical contributions into DfST from within contexts outside of the Global North. We think this is mostly because system innovations and sustainability transitions research has only just started to be diffused in Africa, Asia and Latin America. Despite the concentration of the work listed in Table 1 mostly in Global North, here it must be acknowledged that the Changing the Change Conference [15] included contributions from 27 countries which included some countries of the Global South.

3. Future Directions for Design for Sustainability Transitions

DfST theories have mostly been developed through integration of theories, theoretical models and ideas from research streams which deal with fundamental social and technological change spanning across social sciences, humanities and engineering. This has resulted in a diversity of perspectives on what exactly needs to change in society to achieve sustainability, at what levels of socio-technical systems design can and should intervene in and doing exactly what kind of design. Although this richness of perspectives could be taken as a strength given the complexity of sustainability transitions, DfST would benefit from empirical testing and verification of its several propositions. This would also assist in alignment of its theoretical bases and epistemological embedding of these in design rather than, or in addition to, its parent research domains. This calls for close collaboration of the research groups who have so far been systematically contributing into the area mostly from within the boundaries of their respective research domains. Therefore, the first research direction proposed here is internal integration within DfST itself to delineate a common epistemological grounding from which theories can be tested, verified, improved and further integrated as well as new methodological approaches developed.

The second future research direction relates to the roles design does and can play in sustainability transition projects and processes. Although there is a scarcity of sustainability transitions projects which explicitly reference design theory or practice, the plethora of completed and ongoing projects provide a fertile ground for analysis of the roles and agency of design in transition projects. Design researchers should also seek opportunities to participate in transition research consortiums in order to achieve a more active involvement in both fertilising these projects with design theory and practice, and utilising these projects as case studies in order to expand the current boundaries of DfST.

The potential roles design can play in transition projects and agency of design in transitions should also be researched beyond its already visible activities in the incubation, experimentation and implementation of pilots at the niche level. In addition to these roles which reflect traditionally established roles of design, DfST should aim at continuous engagement in transitions at all levels of the system and with long-term involvement. Open-ended projects need to be established which would put emphasis on processes rather than outputs, and which would target expansive and ongoing impact rather than once-off involvement. Moreover, DfST shall not only focus on starting up new niches but detect and learn to collaborate with established niche endeavors for system transitions and, thus, contribute to the acceleration and scaling up of alternatives. Consequently, DfST should include a radical rethinking of institutional and organisational models along with a redesigning of socio-technical systems and reimagining of socio-ecological relations [49].

It would also be interesting to investigate how some nascent DfS approaches—for example, design for conviviality [50], design for resilience [51] and design for co-habitation [52]—could be supported by and contribute to the theory and practice of DfST. These approaches are ‘small’ approaches in

the sense that their focus is either systemically narrow or thematically limited. Nevertheless, these can be understood as *new ways of designing* in the sense used by Irwin [29] and can inform visions of new systems.

The foundational theories that underlie early contributions in DfST cover complex adaptive systems theories, sustainability science, system innovations and transitions theories, social practice theory and environmental ethics. These are essential theories for informing the future of design practice and they can play a role in sustainability transitions. Nevertheless, DfST can and should also learn from other theories that are currently informing design and penetrating its zone of comfort. For example, design in general should shake the dominance of human-centredness in theory and practice as it is a necessary foundation but too anthropocentric to lead design practice into the future on its own. DfST should develop ways to give voice to the voiceless, both in its epistemology and methodology, as the essential aim should cover creating *just* futures as well as sustainable ones. For this purpose, DfS in general and DfST specifically can learn from feminist theory, animal studies, degrowth studies, post-humanist ethnography, political ecology and literature on the decolonising methodology. Some of this literature has been integrated into design though the contributions of pioneering work in recent years (see, e.g., [53–62]). There is an urgency to further explore the implications of this literature in design, and derive insights and lessons for the development of DfST theory and practice. However, this endeavour should not be one-sided; it is also necessary that this array of design scholarship becomes aware of the relevance of their research (and practice) in regard to sustainability transitions. For example, a recent systematic review on transition intermediaries found that many intermediary actors who play important roles in transition processes (who often operate at the interface of the niche and regime levels) are unaware of their intermediation [63]. Therefore, it is possible that there are more interconnections between design research and practice and sustainability transitions than are currently visible to the eye. This calls for design researchers doing relevant work to start framing their work with references to transitions literature and practice.

DfST is implicitly a project of hope, a hope that is based on the assumption that society can achieve a major transformation towards sustainability in a timely manner and along a smooth path. Nevertheless, in the broader context of academic and public sustainability discourse, hope and despair go hand in hand. This is particularly amplified in regard to climate change. For example, on the one hand, record renewable energy deployment was observed globally in 2016 [64], but on the other hand, the emission reduction targets that are required to reduce the risk of severe climate change are still not being met and the window to limit the average global temperature rise to between 1.5 to 2 degrees centigrade compared to pre-industrial levels is closing [3,4]. The observable impacts of an already changed climate include the migration of animal species to higher altitudes, shrinking glaciers, the loss of sea ice, more intense heat waves, and more frequent and severe extreme weather events. This calls for daring to ask the question: What if transitions do not happen in a timely fashion or do not happen smoothly? Some transitions may happen faster than others, depending on contextual dynamics. In some cases, they may be induced by crises and in some other cases there may be systemic collapses. So, there is not a single type of transition. DfST should expand its theoretical base, as well as the tools used in practice, by learning from several of the transitions typologies proposed [65–68]. Another question that comes to mind is ‘What comes after those transitions that can be societally accomplished in the next 15–30 years, when new dynamic equilibriums have been reached but further transformations will still be needed?’ Therefore, DfST should also start focusing on exploring the what and the how of the contributions that design can make in post-transition contexts.

4. Conclusions

In this article, we have traced the origins and presented the current status of a recently establishing DfS area that links design and sustainability transitions; namely design for sustainability transitions (DfST) or, as popularly known, transition design. The evidence we have presented demonstrates that the emergence of the area dates back to late 1990s. The initial integration of design and sustainability

transitions have been triggered by the The Dutch National Inter-Ministerial Programme for Sustainable Technology Development. As system innovations and transitions theories got matured and developed, sustainability transitions related research emerged and found its place in design scholarship. However, there is a significant diversity of theories influencing theoretical development and practice in this new area. Although this diversity deliberates enriched and novel propositions, and delineates a variety of potential directions the field can move towards, this diversity also indicates a lack of alignment and unification in theoretical foundations.

DfST draws on theories of sustainability science, systems innovations and socio-technical transitions theories, social practice theory, post-normal science, complex adaptive systems theory, product-service systems, futures studies, strategic niche management, needs theory, social psychology, indigenous knowledge, holism, Goethean science, alternative economies. In the upcoming years, there will be need for work in favour of the field to support, improve, complement existing theoretical foundations and develop shared understandings and alignments. There is still a need for investigating further in detail the roles and agency of design in societal change and sustainability transitions since the work around that has been either exploratory or speculative so far. The preliminary practice and real-world applications of this emerging field will potentially provide constructive empirical inputs to these theoretical developments as well as assist the developments of practice-relevant tools and methodologies. Such empiric data might be useful for testing and reconsidering the underlying foundational assumptions of theoretical models encountered in the area. Such reconsiderations would foster the improvement and growth of DfST into to a potentially ground-breaking research area of design theory and practice that deal with sustainability in general and with sustainability transitions specifically. The implications of this emerging area on research, education and practice of design in general and design for sustainability in particular is, thus, significant.

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