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Design as a Catalyst for Sustainability Transitions

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Transitions towards sustainability need for radical and structural changes in the social, cultural and organisational dimensions in addition to technological innovations and infrastructural changes. Sustainability transitions have been a research and practice agenda for several decades. Currently, a new area in design for sustainability field is emerging that bridges the theories and practices of sustainability transitions with theory, education and practice of design. In this paper, we investigate the emergence and evolution of this new area through a literature review of selected publications that represent the current approaches of integrating the theories of sustainability transitions and design. We provide an overview of the current status of the field as well as a comparative analysis of the main contributions regarding their theoretical groundings, sustainability definitions/measures, framings of role of design(ers) and methodological propositions.

sustainable design, design for sustainability, transition design, sustainability transitions

1 Introduction: Sustainability Transitions and There Comes Design

We are going through quite troubled times. This is not the first time; even if we forget about our struggles through millennia with wars, plague and other epidemics, natural disasters, brutal emperors and several other ailments that has shaken our civilisation (and caused the demise of some others') and focus on the last 100 years there have been many moments of existential anxiety for us, "humanity". In the past 100 years, we have been through two World Wars, witnessed horrifying genocides, survived the Great Depression (and few other global financial crises), lived under the threat of a potential nuclear holocaust, been through the long and shivering winter of the Cold War, witnessed two major nuclear plant -one in Chernobyl and one in Japan-, and several severe chemical plant accidents. None of these troubled us - at least in retrospect - as much as the current complex of globally significant, some of which mutually reinforcing, socio-ecological problems. The earlier problems were either human-induced-trauma-on-human, or, in the case of natural disasters, were more or less spatially and temporally contained, even if devastating. Today we are more troubled than ever. For example, we know that the impact of anthropogenic climate change on oceans may last longer than modern human settled societies have been on Earth (Norris



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et al., 2013). If the state of oceans in some hundred thousand years into the future is not a sufficiently cathartic framing of how troubled we are, let's put things into more of a perspective that we can hopefully relate to.

The "Planetary Boundaries" framework (Rockström et al., 2009; Steffen et al., 2015) sets out precautionary boundaries -a safe operating space- for nine critical processes of human-driven environmental change. According to this framework, currently two (biosphere integrity and biochemical flows) out of nine boundaries have been severely breached posing high risk, two of them (climate change and land-system change) breached these boundaries posing increasing risk and two boundaries (novel entities and atmospheric aerosol loading) are yet to be quantified. Only three of the nine boundaries (freshwater use, ocean acidification and stratospheric ozone depletion) are currently not breached. Beyond these nine boundaries, we all face the possibility of abrupt, large-scale changes in Earth system functioning and significant risks to societies and economies worldwide. In addition, emission reduction targets that are required to reduce the risk of severe climate change are still not being met and the window to limit average global temperature rise between 1.5 to 2 degrees centigrade compared to preindustrial levels is closing (Raftery et al., 2017, UNEP, 2017). Raworth (2012), developed the concept of social foundations to complement the planetary boundaries framework and argued for a "safe and just operating space" which lied between the environmental ceiling and social foundations. The social foundations she identified include food security, water and sanitation, health care, education, energy, gender equality, social equity, voice, jobs, resilience. She demonstrated through illustrative indicators that humanity is currently falling below these social foundations for which data are available.

These and numerous other studies triggered the acknowledgment of an urgent need for radical and transformative restructuring of socio-technical systems that meet our needs (Ryan, 2013). Stemming from the acknowledgement of this urgent need, starting from early 1990s, a new area of research emerged out of science and technology studies field and matured over the past two decades. This field is often referred to as system innovations and transitions to sustainability, or shortly, sustainability transitions (Geels, 2005; Loorbach 2010). Sustainability transitions require institutional, social/cultural, organizational as well as technological change (Loorbach, 2010); that is, they need to take place at societal level. Recently, Gaziulusoy and Ryan (2017a) have argued that transitions are creative, technical and political design challenges that require imagining new systems, evaluating system concepts and developing those that are promising and, designing participatory deliberation processes to attend to the political nature of transitions. Ceschin and Gaziulusoy (2016) have analysed the evolution of design for sustainability (DfS) field over a couple of decades since its early conception. Their analysis indicated that the field has enlarged its scope both in terms of timeframes and with references to complexity of problem and solution contexts over the years and moved from a palliative position to one that is strategic. They have identified a new research and practice area emerging in the DfS field since the beginning of this decade responding to the acknowledged urgency of action and the requirement for structural societal transformations, partly influenced by the then maturing system innovations and transitions theories. Ceschin and Gaziulusoy (2016) categorised the contributions in this emerging DfS area under socio-technical innovation level in the hierarchical evolutionary framework they developed. In this framework, socio-technical innovation category resides at the top-most level and subsumes spatio-social, product-service system, and product innovations.

In this article we present a comparative analysis of the main contributions into this new DfS area focusing on their theoretical groundings, sustainability definitions/measures, and proposed methodologies and methods with the purpose of providing an overview and current status of this emerging area and establishing ground for identifying future research directions

2 Design and Sustainability Transitions: A Short History

It is difficult to pin point an exact start for evolution of thought in an area for the same reasons that it is not possible to put an exact date on when a particular species emerged; evolution is a continuum. The best dating practices investigate tangible evidences -traces, remains - left behind to identify the earliest time of appearance. In the case of thought, those evidences consist of text; pieces of writing materialising thought through words. Therefore, we investigate the emergence and evolution of this new DfS field integrating sustainability transitions and design as reflected in writing. Our method of gathering together the written material has two parts. First, as contributors of this emerging area we already have in-depth knowledge of the published work, particularly in the academic fora. This set of publications establish a link between design and sustainability transitions. Second, in order to account for work we may not be aware of and also to include grey literature, we followed a systematic search in google and in main academic databases which cover design titles. As we tried to find those work that integrate design (as a discipline) and sustainability transitions we searched for these and close variants in title, abstract and keywords. We have filtered the search results for disambiguation. Table 1 provides the final list of publications as relevant for our purpose.

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

Resource (by year)	Title	Type of document
Brezet (1997)	Dynamics in ecodesign practice	Journal article
Young et al. (2001)	Exploring sustainable futures through 'Design Orienting Scenarios' – The case of shopping, cooking and eating	Journal article
Cipolla & Peruccio (2008)	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)	Climate Change and Ecodesign	Journal article
Manzini (2009)	New design knowledge	Journal article
Dewberry & Johnson (2010)	Design interventions, prediction and science in the sustainable transition of large, complex systems	Conference article
Gaziulusoy (2010)	System Innovation for Sustainability: A Scenario Method and a Workshop Process for Product Development Teams	PhD thesis
Joore (2010)	New to Improve, The Mutual Influence between New Products and Societal Change Processes	PhD thesis
Kossoff (2011)	Holism and the Reconstitution of Everyday Life: a Framework for Transition to a Sustainable Society.	PhD thesis
Ceschin (2012)	The introduction and scaling up of sustainable Product-Service Systems: A new role for strategic design for sustainability	PhD thesis
Gaziulusoy, Boyle & McDowall (2013)	System innovation for sustainability: a systemic double-flow scenario method for companies	Journal article
Ryan (2013)	Critical Agendas: Designing for Sustainability from Products to Systems	Book chapter
Ceschin (2014a)	The societal embedding of sustainable product-service systems. Looking for synergies between strategic design and transition studies	Book chapter

Ceschin (2014b)	How the Design of Socio-technical Experiments Can Enable Radical Changes for Sustainability	Journal article
Heiskanen et al. (2014)	User involvement and radical innovation: The case of heat pumps in Finland	Book chapter
Gaziulusoy (2015)	A critical review of approaches available for design and innovation teams through the perspective of sustainability science and system innovation theories	Journal article
Gaziulusoy & Brezet (2015)	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)	Transition Design: A Proposal for a New Area of Design Practice, Study, and Research	Journal article
Irwin (2015b)	Transition Design: A new area of design research, practice and study that proposes design-led societal transition toward more sustainable futures	Monograph
Irwin, Tonkinwise & Kossoff (2015)	Transition Design: An Educational Framework for Advancing the Study and Design of Sustainable Transitions.	Conference article
Joore & Brezet (2015)	A Multilevel Design Model: the mutual relationship between product-service system development and societal change processes	Journal article
Kossoff, Irwin & Willis (2015)	Transition Design	Editorial for a journal special issue on Transition Design*
Kossoff, Tonkinwise & Irwin (2015)	Transition Design: The Importance of Everyday Life and Lifestyles as a Leverage Point for Sustainability Transitions	Conference article
Mateu (2015)	Design in Transition, Transition Design	Conference article
Ceschin & Gaziulusoy (2016)	Evolution of design for sustainability: From product design to design for system innovations and transitions	Journal article
Gaziulusoy & Ryan (2017a)	Roles of design in sustainability transitions projects: A case study of Visions and Pathways 2040 project from Australia	Journal article
Gaziulusoy & Ryan (2017b)	Shifting Conversations for Sustainability Transitions Using Participatory Design Visioning	Journal article
Gaziulusoy & Ryan (2017c)	Imagining Transitions: Designing a Visioning Process for Systemic Urban Sustainability Futures	Conference article
Hyysalo, Johnson & Juntunen (2017)	The diffusion of consumer innovation in sustainable energy technologies	Journal article
Mok & Hyysalo (In Press)	Designing for energy transition through Value Sensitive Design	Journal article
*This special issue has 10 articles which are not separately listed here		

The list of publications in the table is indicative of emergence of ideas and themes that now constitute the accumulated knowledge informing the ongoing integrations of design and sustainability transitions. It is not possible for us to discuss each entry in this list in detail within the

scope of this article. Nevertheless, we would like to go over what could be considered as “key points” in the publications timeline that can assist with establishing a historical understanding of origins and development of thought at the intersection of design and sustainability transitions.

Brezet (1997) is the earliest resource that mentions system innovation in the context of design. In this now very difficult to find print article, he identifies four types of *ecodesign innovations* with increasing potential of environmental improvements: product improvement, product redesign, function innovation and system innovation. He explains system innovations as changes that are required in infrastructure and organisations as a result of new products and services. This resembles to an early, perhaps somewhat premature definition of system innovations that is now one of the core terms in sustainability transitions literature. As defined by Geels (2005), system innovations are transitions from one socio-technical system to another. Brezet (1997) refers to The Dutch National Inter-Ministerial Programme for Sustainable Technology Development (Weaver et al., 2000) which took place between 1993 and 2001. This program was then yet-to-be the precursor of system innovations and transitions research. Brezet (1997) states that in this program scenarios and back-casting is used to “develop a vision for sustainable function fulfilment by systems in the year 2040” (p. 23).

Another key point is when the first conference on design and sustainability transitions - Changing the Change Conference - was held in Turin, Italy (Cipolla & Peruccio, 2008). In this conference 138 papers were presented from 27 countries. The conference highlighted that radical change in lifestyles and ways of meeting needs was required and that sustainability had to become the meta-objective for all design research activity. Although not separately listed in Table 1, among these 138 papers, as indicative examples of the content, Ryan (2008b) argued for design-visioning for paradigm change, Vezzoli, Ceschin & Kemp (2008) established a link between design and transition management and Boehnert (2008) discussed what designers can learn from the Transition Towns movement.

Between 2010 and 2012, first PhDs that established a link between design and sustainability transitions were completed. Gaziulusoy's (2010) work was situated at the intersection of sustainability science, system innovations and transitions theories and design theory. Joore (2010), on the other hand, situated his work tightly within industrial design engineering, exploring the mutual influence of new products and societal change processes. Ceschin (2012), 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. These three PhDs were similar in the sense that they all referred to and used multi-level perspective of system innovations (Geels, 2005) 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. Kossoff (2011) on the other hand 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 - 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 (2011), Irwin (2015a) 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 (Irwin, 2015c). In 2015, the first journal Special Issue on transition design was published (Kossoff, Irwin & Willis, 2015).

The other key points include a first, exploratory study on the roles of design in transition processes (Gaziulusoy & Ryan, 2017a), explicit use of particular design approaches in transition projects (Mok & Hyysalo, In Press), and investigations of evidences of user involvement in the design and diffusion of new technologies in transition projects (Heiskanen et al., 2014; Hyysalo et al., 2017).

3 A Comparative Analysis of Contributions at the Intersection of Design and Transitions

According to the analysis presented in the previous section, we observe that origins of integration of design with sustainability transitions goes as far back to late 1990s. At the time, the thinking was situated in ecodesign - the dominant framing at the time of design dealing with sustainability challenges - and predominantly focused on resource related challenges imposed by production-consumption systems. We observe early endeavours of situating *the social* and *everyday life* at the core of DfS dealing with radical system changes in the work of Young et al. (2001). It was inevitable this expansion of scope has come about as, even in the very early connection Brezet (1997) made with design and system innovation, there is 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 is evident in the work of Gaziulusoy (2010), Joore (2010) and Ceschin (2012) who, although focused on product development, saw this activity as systemically situated in the larger context of societal changes. The geographical diversity of Changing the Change Conference of 2008 is evidence that sustainability transitions related thinking in design across the board was well underway before the first PhDs in the area were completed. Late 2000s and early 2010s have seen a significant influence of system innovations and transitions theories (Geels, 2005; Loorbach, 2007; 2010) in DfS work. These theories provided *some foundations* on how socio-technical transformations happen and how they can be steered so that design researchers could start to establish links between design theory and practice and sustainability transitions. The three PhDs mentioned above, although fundamentally based on system innovations and transitions theories, generated a set of theoretical (and operational) frameworks with similarities but also differences. Kossoff (2011), on the other hand, situated his work in philosophy, social ecology, and everyday life discourse without any reference to system innovations and transitions theories.

Table 2. Theoretical foundations of selected work

Contributions	Theoretical foundations
Gaziulusoy (2010); Gaziulusoy, Boyle & McDowall (2013); Gaziulusoy & Brezet (2015)	Sustainability science; complex adaptive systems; system innovations and socio-technical transitions theories; futures studies (scenarios)
Joore (2010); Joore & Brezet (2015)	Industrial design; systems engineering; sustainable product development; system innovations and socio-technical transitions theories
Ceschin (2012); Ceschin (2014a; 2014b)	Product-service systems; strategic design; system innovations and transitions theories; strategic niche management
Kossoff (2011); Kossoff, Tonkinwise & Irwin (2015); Irwin (2015a); Irwin (2015b); Irwin, Tonkinwise & Kossoff (2015)	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

Following this line of thought, in this section we provide a comparative analysis of contributions selected from Table 1 that are representative of the current diversity of work that builds bridges between design and sustainability transitions. In this comparative analysis, initially we try to delineate theoretical origins of these contributions. As all of the work under analysis are highly integrative in their nature, it is not easy to single out a body of literature as *the* foundational theory each contribution is based on; they are situated in or make use of a multiplicity of disciplinary lineages and bodies of literature. 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. We have grouped these together. Table 2 presents theoretical foundations of selected contributions.

In addition to delineating theoretical foundations, we also tried to understand how sustainability is framed and measured, how the roles and agency of design are framed or implicated, and what kind of methodological frameworks and methods are proposed by these contributions.

3.1 Framing and Measures of Sustainability

Gaziulusoy's (2010) work (see also subsequent publications, Gaziulusoy, Boyle & McDowall, 2013; Gaziulusoy & Brezet, 2015) is significantly influenced by the ideas of sustainability science, particularly by complex adaptive systems theories. According to her framing, sustainability is a systemic property therefore talking about sustainability at product level is not possible without references to the system the product is embedded in. Sustainability is not an absolute property; it can only be established relative to the nominal lifespan of the system to be sustained. Whether the subject system has reached its nominal lifespan can only be assessed *ex post facto*. Therefore, sustainability cannot be measured (at least in absolute terms) but sustainable systems can be envisioned and enacted upon across relevant system levels and timeframes. She argues for adoption of the strong sustainability model in system innovations and transitions projects as well as in company strategies which informs product development. Her central focus for intervention is companies because, she argues, companies are critical actors in sustainability transitions; they influence and are influenced by societal visions of sustainability and they frame the direction of product development through strategy.

Joore (2010) does not take up a mission for developing an elaborate frame for sustainability. Instead, he simply adopts a definition from an earlier work by Tukker and Tischner (2006); that is causing minimum negative environmental impact while maximizing social well-being and maximizing economic added value. Because his aim is not to propose alternative theories, but instead through an integrated reading of existing theories, 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, it is understandable he does not confront the challenge of dealing with elusiveness of sustainability as a research term. Ceschin (2012) on the other hand, although minimal, provide some discussion touching on some overarching themes in sustainability discourse such as growth, equity and limits. He argues that sustainability can only be achieved by drastically reducing consumption of environmental resources, at least by 90%, compared to the average consumption by mature industrialised contexts, and by equally distributing them.

Kossoff (2011) is critical of the work of *mainstream* academic work on sustainability as being more about preserving the status quo than challenging the fundamental assumptions upon which our current society has been established. He argues that sustainability requires not only ecological, social, economic, but also cultural, political, existential problems to be addressed so that *everyday life* becomes sustainable *again* across its all *domains*. He is against quantitative framings of sustainability and advocates qualitative understandings that incorporate non-utilitarian, in addition to utilitarian, human activities. He defines sustainability as *wholes of everyday life* and counts self-organization, participation, emergence, multiplicity in unity, intrinsic relatedness, and meaningfulness in the everyday life of specific places as indicators of sustainability. It is understood that the work of Kossoff (2011) has influenced the subsequent discussions and framings in Kossoff,

Tonkinwise & Irwin (2015); Irwin (2015a); Irwin (2015b); Irwin, Tonkinwise & Kossoff (2015) as these do not discuss in detail theories that inform framings of sustainability but reflect the ideas elaborated in Kossoff (2011). The position adopted in these works can be summarised as sustainability being a place-based property of globally networked communities, informed by evolving visions which propose whole lifestyles and diffuses in everyday practices.

3.2 Agency and Role of Design(ers)

In Gaziulusoy's (2010) framing, designers are significant actors in sustainability transitions as they are going to create the new products, services, and meanings within new socio-technical systems. But, despite this significance, they have partial agency in influencing change at societal level. This is partly because their work takes place in the operational timeframe of transitions so they are bound by short-term requirements that are imposed on through company strategy. Therefore, in her theoretical framework, company strategy plays an intermediary role translating diffuse, long-term, societal-level visions of sustainability into concrete decisions at design level in the short-term. Similarly, company strategy plays an intermediary role for design level to take part in societal-level vision-making. According to Joore (2010), the role of design(ers) varies at different system levels from *normal* product design to visualiser and co-thinker of visionary future solutions. This, in a way, is similar to indirect agency as framed by Gaziulusoy (2010). In Joore (2010), the agency of designer is 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. According to Ceschin (2012), designers can (and should) play multiple roles in sustainability transitions. These include designing sustainable product-service systems, designing transition paths for societal embedding of these and designing socio-technical experiments within which new sustainable product-service system concepts be ideated and developed.

Gaziulusoy (2010), Joore (2010) and Ceschin (2012) draw pictures of designers who are more or less similar to current generic designer archetype with somewhat expanded skills and knowledge base as well as implied attitudes and values aligned with sustainability. It is not difficult to imagine these designers being educated in our present university programs. However, the same cannot be said for the picture Kossoff (2011) draws. According to him the fundamental task of the transition designer – and everyone can be one – is to facilitate the emergence of domains of everyday life which have gone into decline through modernity and protect or repair the relationships at all levels of scale that exist between people, nature and artifacts. A transition designer 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 – he/she is a multi-faceted, place-based activist. Irwin (2015a), Irwin (2015b), Irwin, Tonkinwise & Kossoff (2015), rather than the role of design(ers) in detail, qualities of a mindset and posture that transition designers should adopt that are aligned with imagining and bringing into existence place-based sustainable everyday lives.

3.3 Methodological Frameworks and Methods for Design

Gaziulusoy (2010) (also see Gaziulusoy, Boyle & McDowall, 2013; Gaziulusoy & Brezet, 2015) developed an operational tool for the use of design and innovation teams to align their day-to-day decisions and strategic outlook with unfolding and upcoming sustainability transitions. This operational tool - a scenario method - integrated explorative and backcasting scenarios approaches in order to causally link present reality with future aspiration. Ceschin (2012; 2014) also developed a very elaborate tool set for practicing designers. This tool set included tools to formalise SPSS 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.

4 Conclusions

In this paper we reviewed the short history of an emerging DfS area that deal with sustainability transitions. We found that the history of the area goes as far back as to late 1990s, initially influenced by the The Dutch National Inter-Ministerial Programme for Sustainable Technology Development. The maturation of system innovations and transitions theories facilitated the emergence of sustainability transitions thinking in design. Currently, there is a diversity of theories influencing theoretical development and practice in this new area including sustainability science, complex adaptive systems theory, systems innovations and socio-technical transitions theories, futures studies, product-service systems, strategic niche management, needs theory, social practice theory, Goethean science, holism, indigenous knowledge, post-normal science, social psychology and alternative economies. This diversity indicates a lack of unified foundational theory on one hand, on the other hand it presents a picture of potential directions the field can evolve towards. In the coming years, there will be a need for putting effort into developing rigorous theoretical foundations for the field that will support, improve and complement the ones that already exist. There is still a need for further delineating the roles design can play in transitions processes as the work undertaken so far has been mostly exploratory or speculative. The observed preliminary adoption of the field in practice can provide fruitful empirical input into these theoretical developments and also can assist with development of practice-relevant models and tools. Empirically informed theoretical developments can be instrumental in testing the foundational assumptions that seem to have informed some theoretical models proposed so far and can assist in scientific development of this area to potentially become ground breaking in parts of design theory and practice that deal with sustainability in general and sustainability transitions specifically. The implications of this emerging area on research, education and practice of DfS specifically and design in general is thus significant.

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