

THESIS FOR THE DEGREE OF LICENTIATE OF ENGINEERING

Guiding Sustainability Transitions

Backcasting, Experimentation and Social learning

JOHAN LARSSON

Division Physical Resource Theory

Department of Space, Earth and Environment

CHALMERS UNIVERSITY OF TECHNOLOGY

Gothenburg, Sweden 2019

Guiding Sustainability Transitions

Backcasting, Experimentation and Social learning

JOHAN LARSSON

© JOHAN LARSSON, 2019

Department of Space, Earth and Environment

Chalmers University of Technology

SE-412 96 Gothenburg

Sweden

Telephone + 46 (0)31-772 1000

Printed by Chalmers Reproservice

Gothenburg, Sweden 2019

Guiding Sustainability Transitions

Backcasting, Experimentation and Social learning

JOHAN LARSSON

Division Physical Resource Theory

Department of Space, Earth and Environment

Chalmers University of Technology

Abstract

Sustainability challenges including climate change, social injustice, resource depletion and biodiversity loss are becoming increasingly apparent. These challenges can be understood as partly resulting from unsustainable socio-technical systems in society, assumed to require transitions to become sustainable in time. When moving beyond more conventional attempts to analyse and describe sustainability challenges, there is an increasing research interest in solutions-oriented and prescriptive approaches to meaningfully engage with sustainability challenges in various contexts.

The aim of this thesis is to contribute knowledge on how societal transitions can be guided into desirable and sustainable pathways, where social learning is assumed a key process. The many designs and frameworks for engaging with sustainability transitions that prevail in literature seldom provide insights into the contingent nature of its application in its particular context, the prior knowledge and beliefs of participating actors, or an unpacking of how and why (transformative) social learning processes might unfold.

Through inter- and transdisciplinary research and drawing on case studies and ethnographic methods, this thesis includes further development and an empirical evaluation of a backcasting-from-principles process in two settings: a ‘Challenge Lab’ arena that creates space for students to lead sustainability transitions (Paper I), and a regional multi-stakeholder process related to climate policy (Paper II). These studies represent initial attempts to better understand conditions and mechanisms into the kinds of learning that occur in these spaces. Finally, this thesis develops hypotheses on capabilities of sustainability principles in navigating transitions, and particular tools that may be used within and beyond backcasting settings to provide structure in inspiring and supporting conversations on sustainable and desirable futures (Paper III).

Keywords: sustainability transitions, backcasting, experimentation, social learning, reflexive governance, transdisciplinarity, Education for Sustainable Development (ESD)

List of appended papers

- I **Larsson, J.**, & Holmberg, J. (2018). Learning while creating value for sustainability transitions: The case of Challenge Lab at Chalmers University of Technology. *Journal of Cleaner Production*, 172, 4411–4420. <https://doi.org/10.1016/j.jclepro.2017.03.072>
- II **Larsson, J.**, & Holmberg, J. (2019). Sustainability principles in guiding transitions: exploring capabilities through a regional backcasting case. *Draft manuscript*
- III Holmberg, J., & **Larsson, J.** (2018). A Sustainability Lighthouse—Supporting Transition Leadership and Conversations on Desirable Futures. *Sustainability*, 10(11), 3842. <https://doi.org/10.3390/su10113842>

Related publications not included in this thesis

- I Holmberg, J., **Larsson, J.**, Andersson, D., (2015) Challenge Lab: a transformative and integrative approach for sustainability transitions. *Conference paper presented at the 6th International Sustainability Transitions Conference (IST-15)*. Sussex, UK
- II Holmberg, J., **Larsson, J.**, Andersson, D., (2016) Students guiding societal transitions - examples from Challenge Lab at Chalmers University of Technology, Gothenburg, Sweden. *Conference paper presented at Engineering Education on Sustainable Development (EESD-16)*. Bruges, Belgium
- III Holmberg, J., & **Larsson, J.** (2017) Challenge Lab – Learning by engaging in society’s sustainability transitions. *Proceedings for the 10th Researching Work & Learning (RWL) International Conference Series*. Grahamstown, South Africa
- IV **Larsson, J.**, & Williams, S. & Holmberg, J. (2018) Guiding systemic change – a cross case analysis of ‘transition labs’ in Canada and Sweden. *Conference paper presented at the 9th International Sustainability Transitions Conference (IST-18)*. Manchester, UK
- V McCrory, G., & Schöpke, N., **Larsson, J.**, & Holmberg, J. (2018) Governing sustainability transitions: contrasting experimental arenas through the lens of Agenda 2030. *Conference paper presented at the 9th International Sustainability Transitions Conference (IST-18)*. Manchester, UK

Acknowledgements

This licentiate thesis serves as a ‘stepping stone’ towards a doctoral thesis. Not least, it provides the possibility for me to take a step back and reflect upon the research I have been doing and aspire to do. It is also a deliberation of assumptions, thoughts and ideas central in my research, that may invite for further critical and constructive conversations.

This work would not have been possible without my supervisors John Holmberg and Tom Adawi. I would like to particularly thank you John for challenging me, believing in me and always being supportive and available even in seemingly busy times. Tom, thank you supporting me not least with confidence and guidance into research avenues I imagined impossible (and did not even know existed!) less than two years ago.

Also thank you, Erik, Gavin and Niko for your great support in forming and writing this thesis, which is telling about your generosity and support as friends and colleagues also beyond this particular work.

I would also like to thank all my colleagues at Physical Resource Theory, and related colleagues at Engineering Education Research and Environmental Systems Analysis, for which there are too many names to mention on this page (Go to our webpages and you’ll see both names and faces!). And special thanks to all of you associated with Chalmers Initiative for Innovation and Sustainability Transitions.

I would like to direct thanks to all of you I work and have worked with at Challenge Lab, including John, David, Örjan, Daniella, Andreas, Linnea, and all fantastic students over the years.

I would also like to thank the team at Rhodes University – Heila, Mutizwa, Eureta, Daryl, Mike and colleagues – for always being warm and welcoming me with open arms, and all conversations from which I have drawn great inspiration. The same goes for you Steve. I really look forward continuing working with you all.

Special thanks to Erik and David my old roommates, and now Gavin and Jinxi for bearing with me and all the chairs. And thanks Erik for having been a role model and mentor since we met in Intize back in 2010.

Klara, without your understanding and support through this entire process including during my previous education, I would never have been where I am today.

Also, love to my parents, brothers and close friends (you know who you are).

I would also like to direct thanks to Region West Sweden for funding this research.

Table of Contents

ABSTRACT	I
LIST OF APPENDED PAPERS	II
RELATED PUBLICATIONS NOT INCLUDED IN THIS THESIS	III
ACKNOWLEDGEMENTS	IV
1 INTRODUCTION	1
1.1 PROBLEM AND PURPOSE STATEMENT	2
1.2 RESEARCH QUESTIONS	4
1.3 CONTEXT OF THE RESEARCH	6
2 THEORETICAL BACKGROUND.....	7
2.1 SUSTAINABILITY	7
2.2 TRANSITIONS	8
2.3 LEARNING	9
2.4 BACKCASTING FROM PRINCIPLES	10
3 METHODOLOGY.....	13
4 SUMMARY OF APPENDED PAPERS	15
4.1 PAPER I.....	15
4.2 PAPER II.....	16
4.3 PAPER III.....	17
5 DISCUSSION	19
5.1 CONTRIBUTIONS.....	19
5.2 IMPLICATIONS FOR PRACTICE.....	20
5.3 LIMITATIONS	20
5.4 FUTURE RESEARCH.....	21
6 CONCLUSION	23
REFERENCES	25
APPENDED:	
Paper I	
Paper II	
Paper III	

1 Introduction

A number of sustainability challenges are becoming increasingly apparent, including climate change, social injustice, resource depletion and biodiversity loss. These challenges are typically accompanied by complexity and dispute, where their ultimate societal causes are contested and effects dispersed across space and time. In addressing them, long-term gains are typically set in opposition to short-term interests (Hopwood, Mellor, & O'Brien, 2005; Waas, Hugé, Verbruggen, & Wright, 2011; Sen, 2013). To handle the width and depth of many of the challenges, transformative processes of change are deemed necessary to achieve sustainability in time (United Nations, 2015; UNFCCC, 2015; European Environment Agency, 2017).

From a transition¹ perspective, transformative processes of change imply more fundamental changes on a level of 'socio-technical' systems in society. This includes systems of provision- and use of societal functions including energy, mobility, food and water (Grin, Rotmans, & Schot, 2010). Drawing from the work by Rittel and Webber (1973) on 'wickedness', transitional changes in such systems are said to be complex, uncertain and ambiguous and can hence not be planned or controlled in a traditional sense. Rather, their speed and direction are said to be possible to influence (Rotmans, Kemp, & van Asselt, 2001). Deliberate attempts of doing so include reflexive modes of governance, which seek to coordinate actors and resources towards a common purpose, and emphasize collective experimentation and learning (Smith, Stirling, & Berkhout, 2005; Voss, Bauknecht, & Kemp, 2006; Voss & Bornemann, 2011). Objects of focus are often systems considered unsustainable, whose development is attempted to be guided into sustainable and desirable pathways via strategic 'acupuncture interventions' (Loorbach, Frantzeskaki, & Avelino, 2017).

Backcasting is a futures-oriented approach that is used to guide various change processes in the context of sustainability. In reflexive governance, backcasting is often used as a particular approach to navigate transitions in real-world settings (Vergragt & Quist, 2011). Backcasting has gained traction for its potential to complement mainstream planning processes (Giddens, 2009), and has been recognized a key process to guide the realisation of Agenda 2030 with its 17 Sustainable Development Goals (SDSN, 2015). In its essence, backcasting seeks to articulate desired futures and then analyse how they might be achieved (Robinson,

¹ See further Feola (2015) and Hölscher, Wittmayer, and Loorbach (2018) for discussions into the similarities and differences between the notions of 'transition' and 'transformation'.

Burch, Talwar, O’Shea, & Walsh, 2011). It hence considers the future as something to be created, rather than something pre-determined or a matter of probability (Robinson, 1988, 1990).

As sustainable futures remain to be created, it implies work at the border of the unknown, where social learning becomes a key process (Robinson, 2003; Armitage, Marschke, & Plummer, 2008; Wals, 2009; Reed et al., 2010). In particular, it is argued that processes of transformative social learning – understood as the level of beliefs, values, actions and societal structures – are central in the sustainability discourse (Budwig, 2015; Macintyre, Lotz-Sisitka, Wals, Vogel, & Tassone, 2018). Such learning is often referred to as ‘learning what is not yet there’ (Engeström, 2016). Transformative social learning explores the potential of learning to produce new objects, practices and activity patterns, in addition to the mere construction of novelty in the minds of the learners.

1.1 Problem and purpose statement

When moving beyond more conventional attempts to analyse and describe sustainability challenges, there is a growing research interest in solutions-oriented and prescriptive approaches to meaningfully² engage with such challenges in various contexts. These developments can be identified in transitions- as well as in sustainability-oriented research that include both descriptive-analytical as well as process-oriented and prescriptive approaches. Yet, the two fields of transition and sustainability research lack general integration (Schäpke, 2018). Smith, Stirling, and Berkhout (2005) remind us that ‘naturally’ unfolding transitions (such as the shift from a horse- to a car-based transportation system (Geels, 2005)) may not necessarily guarantee sustainability. And maybe not surprisingly, convincing understandings of sustainability can be argued necessary but insufficient for transitions towards these ends to come about. A key challenge in transitions research is to understand and explain not only transitional change in societal systems, but also how such change processes can meaningfully be guided into sustainable and desirable pathways.

Sustainability research primarily gravitates around dynamics and sustainability of coupled human-environment or socio-ecological systems, with little emphasis on how (future) transformative processes of change in such systems may be guided in desirable pathways (Kates, Clark, Corell, & et al, 2001; Miller, 2013; Bai et al., 2016). In addition, sustainability research is often more concerned with problematization and criticizing the concept, with little ambition to link emergent understandings of sustainability to (potential) societal processes of change. In

² Meaningful in this context imply both that the engagement in fact contributes to sustainability to some extent, and that it provides learning for those involved.

transitions research, primary attention is paid towards socio-technical systems and dynamics of historic events of disruptive change (Geels, 2002; Grin et al., 2010; Geels, 2011; Markard, Raven, & Truffer, 2012). Engagement with sustainability can be argued to generally fall short of moving beyond statements where the term is considered as merely ‘purpose and direction’ of potential (future) processes of change (van der Helm, 2009). Additionally, when efforts are made to engage, sustainability is often referred to as low-carbon, environmental performance or factor ‘4-10’ (e.g. Smith, Vofß, & Grin, 2010; Geels, 2011; Geels, Berkhout, & van Vuuren, 2016).

To date, sustainability transitions research on the level of context and generative mechanisms remains underexplored and deserves greater attention. Prescriptive and process-oriented approaches to sustainability transitions typically include elements of both sustainability and transition research strands. These approaches come in the form of reflexive governance frameworks (Folke, Hahn, Olsson, & Norberg, 2005; Loorbach, 2007, 2010; Olsson et al., 2006; Steffen et al., 2011; Loorbach et al., 2017) and are, to various degrees, informed by backcasting (Vergragt & Quist, 2011). While several convincing conceptualisations and case studies exist (Grin et al., 2010; Loorbach & Rotmans, 2010; Voss & Bornemann, 2011), more research is needed to uncover the contingent nature of their application in particular contexts. Such research would include inquiry into prior knowledges and beliefs of participating actors, the actual role of process and its sequencing and scaffolding (which may be extensive). To date, studies in sustainability transition spheres towards these ends are rare (see Forrest and Wiek (2014) for an exception). By complementing these contributions, the search for evidence-based approaches (Caniglia et al., 2017) would potentially benefit in two different ways. Firstly, from greater explanation on the level of how and why certain outcomes were produced by certain processes in particular contexts (Pawson & Tilley, 1997). Secondly, such research would allow for a more theoretical understanding and meaningful transfer across cases on a level of generative mechanisms.

Although the importance of social learning has received considerable attention in the context of transitions research (Robinson, 2003; van de Kerkhof & Wieczorek, 2005; Rotmans & Loorbach, 2008; Voss & Bornemann, 2011), some aspects of it are not well conceptualized for empirical analysis and/or development of theory fit for the phenomenon under study (Pahl-Wostl, 2009; Reed et al., 2010; Bos, Brown, & Farrelly, 2013; Beers, Mierlo, & Hoes, 2016; Van Poeck, Östman, & Block, 2018). Little emphasis is put on understanding and explaining how processes of social learning unfold in sustainability transitions (Van Poeck et al., 2018). In particular, there is a call for engaging with questions related to how one might tap into the potential of processes that facilitate social learning that is also transformative and capable of expanding current knowledge boundaries (Lotz-

Sisitka, Wals, Kronlid, & McGarry, 2015; Engeström, 2016; Macintyre et al., 2018). These questions are commonly present and increasingly addressed in the context of Education for Sustainable Development (UNESCO, 2014) and related research (Wals & Jickling, 2002; Cortese, 2003; Sterling, 2011; Barth & Michelsen, 2013; Lotz-Sisitka et al., 2015).

The purpose of this thesis is to contribute knowledge on how societal transitions can be guided into desirable and sustainable pathways, acknowledging that such processes presuppose social learning. Given this ambition, this thesis contribution is twofold. Firstly, it suggests approaches that integrate the concepts of sustainability and transition. Secondly, it critically evaluates and further develops a backcasting-from-principles process in reflexive governance discourse.

1.2 Research questions

As mentioned above, this thesis primarily engages with topical aims of how sustainability can be approached in a meaningful way in the context of transition, through the evaluation and development of process-methodological approaches for guiding societal transitions into sustainable and desirable pathways. With a focus on backcasting from principles, the topical aims are explored in three interrelated ways by engaging with the following research questions³:

- i. How can a learning environment create value in support of society's sustainability transitions inside as well as outside higher education institutions? And what would such learning environment mean for the students and stakeholders involved?
- ii. What are key capabilities of sustainability principles to support navigation in sustainability transitions?
- iii. How can a conceptual framework be created to inspire and support conversations on desirable and sustainable futures?

Research questions i. and ii. have primarily been addressed in Paper I and II, where practical applications of backcasting from principles have been studied in two different contexts: 1) within higher education and 2) in a multi-stakeholder process related to regional climate policy. These studies and their guiding questions do not intend to determine whether the process studied works or not; they are instead based on a more nuanced understanding underpinned by critical realism (Danermark, Ekström, Jakobsen, & Karlsson, 2002; Sayer, 2002; Bhaskar, 2008) – what works, for whom, and why? (Pawson & Tilley, 1997). They also seek to explicitly relate to

³ Partly modified in relation to their particular formulations in Paper I-III to provide better readability in the overall thesis. The research questions are presented in chronological order as they appear in the papers.

Introduction

theories of learning. To date, Papers I and II have provided exploration and indications of effects of interest (including learning outcomes and transformative change), but it remains to be answered what it is that produces those effects. Inquiry into such questions will be made more explicit in the final papers towards the doctoral thesis.

The third research question is primarily addressed in Paper III, which partly originated from insights during the analysis of data in Paper I and II. Simply put, it assumes that conversations on sustainable and desirable futures on a level of principles do not naturally ‘happen’, but demand scaffolding and support, not least to also become transformative.

Part of this research has been conducted through inter- and transdisciplinary approaches where one listens to societal needs and challenges, co-designs approaches for handling the same and seeks to produce results that are useful for both societal and research practice (Klein et al., 2001; Hirsch Hadorn, 2008; Talwar, Wiek, & Robinson, 2011; Lang et al., 2012; Brandt et al., 2013; Lotz-Sisitka et al., 2016; Scholz, 2017). This approach to research also draws on ‘mode-2’ (Gibbons et al., 1994) and post-normal science (Funtowicz & Ravetz, 1993).

The choice of sustainability transitions as the main object of this thesis deserves some comment. Sustainability can be considered an ‘essentially contested’ object, containing normative, ethical and moral ideals, whose particular meaning deserves to be negotiated in its particular time and place (Jacobs, 1999; Robinson, 2004). Transitions represent more fundamental processes of societal change that inherently create ‘winners’ and ‘losers’ (Shove & Walker, 2007; Meadowcroft, 2009). Such processes of change may be considered undesirable as they challenge assumed abilities of societies to be in control, yet they are often argued inevitable in our current times: either as the deliberate response in properly handling the challenges (and responsibility) of sustainability, or as a consequence when facing the effects of not handling sustainability properly (as is often the case in climate change discourse) (Elzen, Geels, & Green, 2004; Grin et al., 2010; Swilling & Annecke, 2012; Fazey et al., 2018).

The emphasis on developing methodological approaches for engaging with transitions has been influenced by three interlinking trends at science-society interfaces: 1) the societal concern of and attempts to respond to sustainability challenges in meaningful ways, 2) the growing field of sustainability transitions research (Markard et al., 2012; STRN, 2017) and the 3) emerging need to engage with and potentially develop concepts of learning that are relevant for transitional processes of change.

1.3 Context of the research

The cases in this thesis are situated in West Sweden with a particular focus on socio-technical transitions to sustainability. Sweden experiences a relatively high level of social welfare, and systems seeking to fulfil societal functions such as energy, mobility and food do in general ‘work’. However, such systems are both dependent on processes considered unsustainable in the long run, as well as subject to continuous incremental and (potentially) disruptive change in relation to e.g. technology, infrastructure, policy, markets, legislation, norms, knowledge and behaviour that make up these socio-technical systems.

Finally, my formal training is in engineering but I have always been interested in the social⁴. I am part of a research group at Physical Resource Theory ‘Guiding Sustainability Transitions’ that is also part of the bigger research node of Chalmers Initiative for Innovation and Sustainability Transitions.

Attempts are also in the making of doing comparative work beyond the context of Sweden, so far in collaboration with research situated in South Africa and Canada.

The remainder of this thesis is structured in the following way. In Chapter 1, I introduced the central discourse in which this thesis is situated, which included an outlining of research gaps, problem and purpose statement, research questions and context of the research. In Chapter 2, I elaborate on central theoretical considerations within this thesis, with particular focus on sustainability, transitions and learning. Chapter 3 specifies the overarching methodological approach guiding this thesis and outlines the specific methods employed in this thesis. Chapter 4 comprises a summary of the primary results generated by papers I, II and III, In Chapter 5, these contributions are then discussed as a whole, before pointing towards implications for practice, limitations and ideas for future research. This thesis then closes in Chapter 6 with a short conclusion of the completed research to date, and reconnects with the research aim and questions that were introduced in Chapter 1.

⁴ N.b. that this does not necessarily make my work fall into the category of social engineering

2 Theoretical background

The following chapter aims to introduce the reader to key concepts of this thesis, with an emphasis on sustainability, transitions and learning (Figure 1).

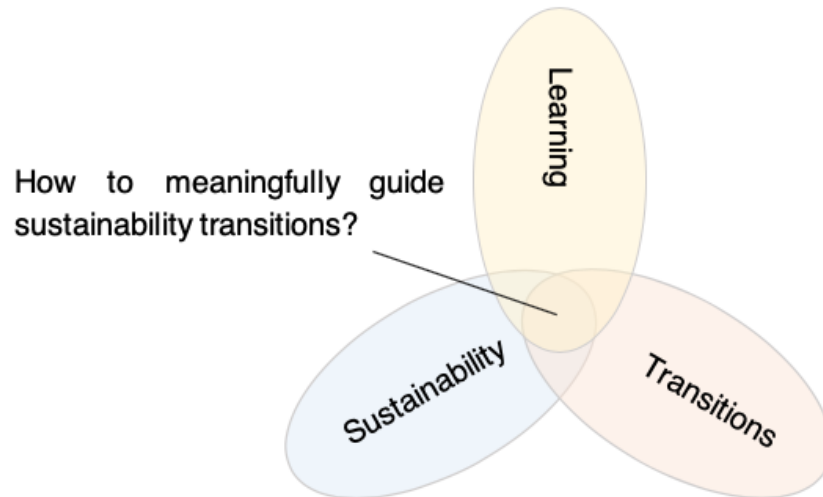


Figure 1 – This thesis integrates concepts of sustainability, transitions and learning, and it has backcasting from principles as the primary object of focus, seeking to understand how to meaningfully guide sustainability transitions.

This chapter seeks to provide a sufficient overview of sustainability, transitions and learning as central theories and concepts of this thesis, all of which the reader has been introduced to in Chapter 1. Whilst I acknowledge that this is not the first time these have been considered in combination, I maintain that this combination arguably remains underexplored (Pahl-Wostl, 2009; Beers, Mierlo, & Hoes, 2016; Macintyre, Lotz-Sisitka, Wals, Vogel, & Tassone, 2018).

2.1 Sustainability

Humanity is suggested to live in a new era of the Anthropocene (Crutzen, 2002) where human activity is the main driver for planetary change. Most conceptual work on sustainability (and sustainable development) relates to policy advancements via work by the United Nations (UN) and associated bodies. These include (to name a few): the acknowledgement of unsustainable human interactions with the environment (UNEP, 1972), inter- and intra-generational justice and human needs (WCED, 1987), the three dimensions: social, ecological, economic (UNCED, 1992; United Nations, 2002) and the more recent Agenda 2030 with the 17 Sustainable Development Goals (United Nations, 2015) also acknowledging the Paris Agreement on climate change (UNFCCC, 2015).

Within the sustainability discourse, research contributions that have achieved much attention over the last 30-50 years include the ‘Spaceship earth’ (Boulding, 1966),

Limits to Growth (Meadows, Meadows, Randers, & Behrens, 1972), the ‘steady-state economy’ (Daly, 1973), ecological footprint (Wackernagel & Rees, 1998), planetary boundaries (Rockström et al., 2009) and the ‘doughnut’ (Raworth, 2012). A key realization within this discourse is that the societies we have built up and live in are dependent upon certain processes to satisfy our needs (and desires (Bauman, 2000)), and that such processes may in turn be dependent on finite resources and produce various side-effects in society and nature. This coupled interaction – between societal demands and resources that sustain them – produce undesirable effects such as climate change, social injustice and biodiversity loss. The aforementioned challenges are typically characterised as being complex, systemic and long-term (Holmberg, 1995; Hopwood et al., 2005; Sneddon, Howarth, & Norgaard, 2006; Waas et al., 2011).

This thesis sees sustainability as an inviting concept for those who share the concern about the possibilities for human and planetary flourishing over time. It is recognized that sustainability is an essentially contested concept containing moral and ethical ideals that need to be negotiated in their particular time and place (Jacobs, 1999). It is commonly argued that sustainability is to be considered a moving object, and is more about process than end-states. Such processes can still be informed by knowledge including e.g. social, ecological and economic consequences of various actions in society (Cf. Robinson (2004)).

Understanding and explaining change at meso-level systems is the primary object of focus in sustainability transitions research (STRN, 2017). The ‘meso-level’ operates in between and complements ‘macro-level’ approaches to societal change and sustainability (e.g. exploring questions related to capitalism and modernity) and ‘micro-level’ approaches (e.g. exploring questions related to individual behaviour).

2.2 Transitions

As mentioned in the introduction of this thesis, a starting point in transitions research is that many of the sustainability challenges we face are due to unsustainabilities in socio-technical production and consumption systems. These systems are configured around elements of technology, infrastructure, policy, markets, legislation, norms, knowledge and behaviour (Geels, 2002, 2011). They are typically characterised by various ‘lock-in’ effects making development and realignment rather path-dependent and incremental, primarily due to vested interests, economies of scale and sunk investments (Geels, 2002; Grin et al., 2010; Smith et al., 2010).

A key assumption is that that incremental change provides insufficient potential for achieving sustainability in time in most socio-technical systems (primarily in the western world). Rather, transitions are needed into new systems configurations (innovation at a systems level) (Elzen et al., 2004; Elzen & Wieczorek, 2005).

Transitions hence represent deeper and more radical transformative change of societal systems, and are typically long-term, contested and open-ended processes that span across various actor-groups, levels and domains (Markard et al., 2012; Loorbach et al., 2017).

Transitions are often considered emergent processes, attributed with the characteristics of complexity, uncertainty and ambiguity (Rotmans & Loorbach, 2008; Schot & Geels, 2008; Sharpe, Hodgson, Leicester, Lyon, & Fazey, 2016). These characteristics make transitions ‘unmanageable’ as they cannot be controlled and planned in a traditional sense (Cf. Rittel & Webber, 1973; Funtowicz & Ravetz, 1993). Rather, it is said that transitions can be influenced (Rotmans et al., 2001). Attempts to understand and influence transitional dynamics typically complement conventional governance approaches with ‘reflexive modes’ of governance (Smith et al., 2005; Voss et al., 2006; Rotmans & Loorbach, 2008). Such approaches emphasise collective learning and experimentation while seeking to coordinate actors and resources towards strategic ‘acupuncture interventions’ (Loorbach, 2014) that induce, guide and accelerate transitional processes of change into sustainable and desirable pathways.

2.3 Learning

Sustainability transitions both come about and are mediated by interactions between technology, policy/power/politics, economics/business/markets, and culture/discourse/public opinion (Geels, 2011). From this understanding, one might perceive, analyse or even presuppose sustainability transitions to be processes and challenges of learning (Holmberg, 1995; Wals, 2009; Macintyre et al., 2018). In particular, the interactive element of these learning processes implies that it is learning that is social – taking place not only within the cognitive domains of the learner, but also in relations and structures including the development and negotiation of novel and shared practices (Lave, 1991; Wenger, 1998; Sfard, 1998), change in understandings, meanings, norms, identities and cultures (Pahl-Wostl, 2009; Reed et al., 2010; Engeström & Sannino, 2010; Macintyre et al., 2018).

Most advances (and research mobilization) within the learning sciences have been within formal educational settings (Engeström, 2016). Yet, cases of transition can arguably be analysed as a process of learning in informal settings beyond those which takes place in the context of the classroom. Here, learning can be understood as the situated and unfolding process when engaging with authentic and unscripted problems (Budwig, 2015) and as an open-ended search and exploration (Cf. March, 1991). Typically, it has not been established in advance what is to be learnt; rather, it is an emergent property of the process (Engeström, 1987, 2016).

Within sustainability spheres, a focus on learning is most clearly articulated within Education for Sustainable Development (ESD), Environmental Education and Sustainability Education. In an expert review, Tilbury (2011, see p. 8) conceptualizes such learning to include processes of learning: (1) about sustainable development, (2) to ask critical questions, (3) to clarify one's own values, (4) to envision more positive and sustainable futures, (5) to think systematically, (6) to respond through applied learning, and, (7) to explore the dialectic between tradition and innovation.

2.4 Backcasting from principles

Reflexive governance approaches often draw from methodologies of backcasting (see further Quist, Wittmayer, Van Steenbergen, and Loorbach (2013)). In short, backcasting seeks to articulate desired futures and analyse how they might be achieved (Robinson et al., 2011). In this sense, backcasting complements forecasting approaches that ask questions concerning 'what will happen?' and scenario approaches asking questions about 'what could happen?', with the more explicit normative orientated question of 'what should happen?' (Robinson, 1990; Dreborg, 1996; Holmberg, 1998; Vergragt & Quist, 2011). Backcasting is considered particularly useful when (Dreborg, 1996, p. 816):

- *“the problem to be studied is complex,*
- *there is a need for major change,*
- *dominant trends are part of the problem,*
- *the problem to a great matter is a matter of externalities,*
- *the time horizon is long enough to allow considerable scope for deliberate choice”*

Backcasting from principles (Holmberg, 1998) is a particular approach to backcasting (Figure 2) that does not seek to envision desirable and sustainable future situations in detail. Rather, it articulates the future on a level of sustainability principles as a frame for many possible desirable futures (Holmberg & Robèrt, 2000). Over the years, this approach has been applied in a number of sustainability transition processes in various contexts and at different scales and levels (see Broman and Robèrt (2017) for an overview).

Theoretical background

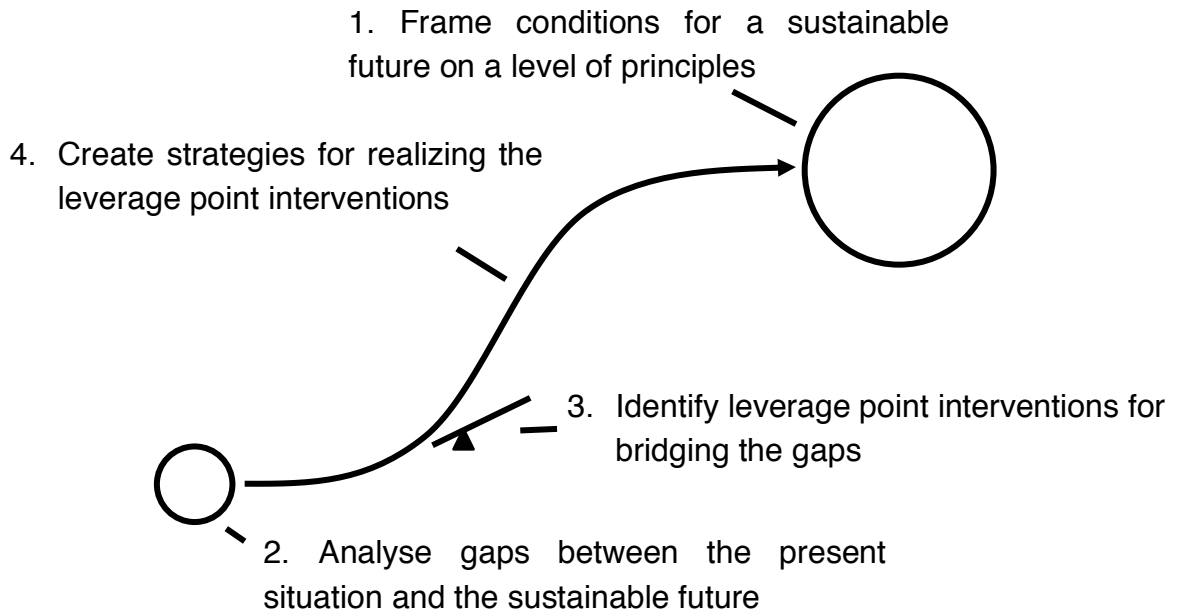


Figure 2 – Sequential steps in backcasting from principles, building on Holmberg (1998) and Holmberg and Larsson (2018).

The process outlined in Figure 2 is often preceded with the formulation of a ‘meta-question’ that is open and inviting, yet focussed around a thematic object such as an area, system or issue to be handled. This thematic focus become the starting point for the invitation of relevant actors to co-create and explore. Such thematically-centred exploration takes place in a process guided and scaffolded by the backcasting steps, whereby associated tools are chosen based on the particular context, theme and purpose of the process.

3 Methodology

This chapter is an attempt to make explicit the methodological approach, its theoretical basis, and the specific research methods employed in this thesis. Methodology can be considered that which lies in between philosophies of science and the methods and procedures used to guide particular studies. Considering science as a social activity (e.g. Mendelsohn, 1977), questions on methodology and methods become practical questions, to be considered in relation to the character of the research object and purpose of the investigation (Danermark et al., 2002).

I primarily draw from a critical realist ontology assuming a reality independent of human thought including structures and mechanisms with the power of making things happen in the world, that we may or may not observe, experience and understand (Bhaskar, 2008). From this perspective, knowledge about reality is dependent on our language and the concepts we make, hence theory-laden and theory-dependent (Kuhn, 1970; Popper, 1972). Theory, in turn, is abstraction from concrete observable reality into ordering frameworks, conceptualizations, hypotheses or explanations (Danermark et al., 2002).

I have studied social settings, whose complexity arguably makes it difficult, or even impossible, to control all variables of interest across levels ranging from individuals, via groups and organizations to societies. For this reason, and in line with the research questions stated in the introduction, I have relied predominantly on a qualitative research approach.

Qualitative research is oriented towards questions of ‘how’ and ‘why’, where one seeks to understand how people experience phenomena in the world. To better understand the nature of qualitative research, it is often contrasted with quantitative research that commonly works with (including but not limited to): (1) numbers rather than words, (2) large and random samples rather than small and non-random samples, (3) hypothesis testing rather than exploring experiences, (4) deduction rather than induction, and (5) with roots in positivism rather than interpretivism (Merriam, 1998; Bryman, 2012).

Emphasis in this thesis has been on understanding the meanings that actions, processes and events have for participants, and seeking explanations of what produces those⁵. Such explanations demand inductive and deductive thought operations to be complemented by abductive and retroductive reasoning (Danermark et al., 2002; Sayer, 2002). Further, as qualitative research is often put

⁵ See 5. Discussion and in particular the section on further research as this mode of explanation is yet to come

in opposition with quantitative research rather than considered complementary, these authors introduce the notions of intensive and extensive research procedures to transcend the divide. Typical research questions for intensive research focus on how a process works in a particular case or a small number of cases, and what produces certain changes in relation to what people did. In extensive research one typically searches for regularities, common patterns and distinguishing features of populations and how widely certain characteristics are distributed or represented (ibid.).

In terms of specific qualitative methods, case studies and ethnography are considered well-suited for acquiring knowledge about mechanisms whose effects may vary depending on context or circumstances (Pawson & Tilley, 1997; Danermark et al., 2002). In this thesis, a case study approach (Stake, 1995; Bassey, 1999; Flyvbjerg, 2006) has primarily been used to explore the broader phenomenon of backcasting, where the choice of case has been based on accessibility. Ethnography is useful for studying social processes in authentic settings as they unfold. In line with an ethnographic tradition, data was collected through observations of actions and interactions in natural settings and complemented with semi-structured interviews, focus group interviews, surveys, and documents. Data analysis has primarily built upon inductive thematic formation (Aronson, 1995; Braun & Clarke, 2006), which have then been contrasted with study purposes and theoretical frameworks for interpretation, re-contextualisation and explanation. Key criteria during these procedures have been validity, trustworthiness and transparency.

4 Summary of appended papers

Below the three papers included in this thesis are briefly summarized. In the next chapter, I discuss the main contributions of the thesis as a whole, as well as implications for practice, limitations and ideas for future research.

4.1 Paper I

The purpose of the first paper of this thesis (Larsson & Holmberg, 2018) was to position Challenge Lab in an Education for Sustainable Development (ESD) discourse, and make an initial investigation into what the engagement in the Lab means for the students as well as the stakeholders involved. Challenge Lab is an arena guided by a backcasting approach and situated in the context of higher education. This arena seeks to create space for and support students in developing leadership skills essential for sustainability transitions.

Challenge Lab represents a particular type of institutional innovation that seeks to situate the 'classroom' in-between the different university departments, and in-between the university and societal actors, including the private- public sector, civil society and NGOs. The space for learning becomes the situated setting in which students engage with authentic problems (complex sustainability challenges) in an authentic context (e.g. multi-stakeholder collaboration, in-between organizations). Apart from its direct educational dimension, Challenge lab also signifies a strategic move for Higher Education Institutions (HEIs) to build capacity in handling societal challenges in collaboration with stakeholders in society, integrating functions of research, innovation and outreach. Challenge Lab is structured around a backcasting from principles approach (Figure 2), where each step is accompanied by an outside-in and an inside-out dimension, and where outside-in refers to the 'objective' reality external to self, and inside-out refers to one's 'subjective' inner realities. Both are acknowledged and argued to be important in transitional processes of change (Holmberg, 2014).

ESD seeks to integrate sustainability into teaching and learning, empower learners to take action for the same (UNESCO, 2014), and challenge the way educational institutions are structured (Cortese, 2003; Lozano, 2006). ESD pedagogies often attempt to engage students in inter- and transdisciplinary processes with deep student engagement (Vare & Scott, 2007; Sterling, 2011; Lotz-Sisitka et al., 2015). Despite these ambitions, most ESD initiatives involve students as knowledge consumers rather than knowledge producers (Tilbury, 2016). Moreover, most research on innovative learning environments in this area is primarily conceptual or descriptive, with empirical studies primarily using a quantitative post-evaluation approach, focusing on student satisfaction (ibid.).

Using a case study approach (Basse, 1999) in combination with ethnographic methods, this study analysed three student cases in-depth. Data was collected through process-related documents of Challenge Lab, published master's theses, observations, group and individual interviews (semi-structured), and a questionnaire administered to the main involved stakeholder(s).

Results suggest that the students managed to achieve meaningful learning in terms of tools to navigate openness and uncertainty, self-awareness and empowerment, while also creating value for stakeholders in society by taking temporary ownership of 'in-between issues', building social trust and relations, and challenging underlying assumptions. While this study is to be considered an initial attempt to evaluate a lab-based learning environment engaging with sustainability transitions, some results may serve as inspiration for the design of similar lab-based initiatives in other contexts. It also, in line with Tilbury (2016), highlights the potential value of acknowledging students as a particular societal actor with relatively unique capabilities to contribute to sustainability transitions.

4.2 Paper II

The purpose of the second paper in this thesis (Larsson & Holmberg, 2019) was to test and look more specifically into the potential of sustainability principles to navigate and guide transitional processes of change.

It studied a regional climate strategic process in West Sweden. The process engaged some 100 stakeholders following a participatory backcasting from principles approach to identify areas of intervention for ensuring a desirable and sustainable low-carbon transition of the region.

The consideration of sustainability transitions as complex, uncertain and ambiguous processes of change imply that decisions and actions have to be made under 'wicked' circumstances (Cf. Rittel & Webber, 1973; Funtowicz & Ravetz, 1993; Rotmans et al., 2001). To navigate and make sense under such conditions, principles might work to support purposeful thinking, action and reflection (Holmberg & Robèrt, 2000; Patton, 2017).

It first theorized potential capabilities of principles, and then compared those with data from the regional climate strategic backcasting process. It followed an exploratory case study approach to reduce bias towards initial propositions on what principles might be capable of doing, drawing from data sources including a pre-post evaluation survey adapted from Walter, Helgenberger, Wiek, and Scholz (2007) and Wiek, Talwar, O'Shea, and Robinson (2014), process-related documents, participant observation and semi-structured interviews.

This study identified effects related to the principles-oriented approach among the participating actors, and perhaps more interestingly on the level of the project group

who organized the sessions, building on the view of backcasting as a process of social learning (Robinson, 2003).

The study was concluded by the formulation of a set of hypotheses on capabilities of principles, that under favourable circumstances might prevail: 1) thinking beyond what currently is (escaping present unsustainable systems), 2) thinking broad (considering several sustainability aspects in parallel), and 3) thinking together (creating shared meaning of different concepts) about sustainability. The hypotheses were then positioned within topics in sustainability transitions- and related research, before ideas for further research were suggested. These included critical scrutiny of the hypotheses formulated and in-depth studies into the conditions and mechanisms of principles-oriented work.

4.3 Paper III

The purpose of the third paper in this thesis (Holmberg & Larsson, 2018) was to create a conceptual framework with a set of categories to support conversations on sustainability, consisting of the following categories: basic (seeking upstreams ‘first-order’ mechanisms that are key for the dimension), sufficient (seeking to cover all major aspects of the dimension), and non-overlapping (seeking internal homogeneity and external heterogeneity (Patton, 1990)).

The study partly builds on a need identified in the first two studies of this thesis, namely how to better inspire and support conversations on desirable futures. Such conversations play an essential role of backcasting processes while also being a key challenge in the same.

It argues for the need to support conversations on sustainability whilst neither strongly prescribing what sustainability is and is not, nor leaving the term completely open to construct in each particular setting. This particular perspective is referred to as a ‘balanced approach’. A set of choices were then made and argued for, relating to the dimensional-approach towards sustainability and the search for categories with the criterion of being basic, sufficient and non-overlapping. Existing frameworks and pre-established categorisations were collected through a qualitative literature review, and thematically analysed in relation to the basic, sufficient and non-overlapping criterion.

Through a qualitative literature review, thematic analysis and contextualisation, this study reviewed and mapped contributions on social, economic, ecological and ‘human needs and wellbeing’ sustainability into a conceptual framework, visualised as a lighthouse (Figure 3).

The lighthouse may be of value in processes guiding (socio-technical) transitions towards sustainability in three different ways: (1) by attempting to bridge the issue of transition with that of sustainability, (2) as part of a backcasting process, and (3) in modes of transdisciplinary research where relevant actors take part of the conversation.



Figure 3 – The conceptual framework visualized in a ‘lighthouse’ model aims to inspire and support conversations on sustainable futures. On top of the lighthouse lies the human needs and wellbeing dimension. Depending on how these needs are met, this dimension influences the other dimensions, and provides direction and purpose. The lighthouse rests on the ecological dimension. The social and economic dimension are understood as structures combining the two other dimensions, and are also in themselves critical for sustainability. The lighthouse might be especially useful in backcasting processes. Needless to say, there are also interdependencies between the dimensions, and to be relevant the categories must continuously be revised.

5 Discussion

Below, I discuss the main contributions of this thesis, implications for practice, limitations and areas for further research. The purpose of this thesis was to contribute knowledge on how societal transitions can be guided into desirable and sustainable pathways, acknowledging that such processes presuppose social learning. It engaged with topical aims including how sustainability can be approached in a meaningful way in the context of transitions, and sought to evaluate and develop process-methodological approaches for guiding societal transitions into sustainable and desirable pathways.

5.1 Contributions

This thesis includes the empirical evaluation of backcasting processes in particular contexts, and development of tools that may be used within and beyond backcasting settings. In this way, it contributes to research on and development of transition governance frameworks. More concretely, contributions include positioning and evaluation of a specific curriculum innovation initiative (Challenge Lab) into the context of ESD (Paper I), development of hypotheses on capabilities of sustainability principles (Paper II), and a conceptual framework to provide structure in inspiring and supporting conversations on sustainable and desirable futures (Paper III).

In particular, contributions to transition governance frameworks have been made on a level of process. The idea of ‘staying with the question’ has been considered a key potential to unlock transformative potential (if any) in backcasting, which at the same time has been identified as a key difficulty in such processes. Similar phenomena have been reported in previous research on backcasting and scenario work, where bias towards the present and the past seems to limit transformative thinking about the future (Ascher, 1979; Ringland, 2002; Vergragt & Quist, 2011). Paper II sought to unpack what potential principles hold and Paper III developed a coherent framework to balance the tendency of ‘running for solutions’ with ‘staying with the question’ related to the purposes and directionality of transitions.

Transformative social learning has been argued to be key for meaningful navigation in sustainability transitions. Within ESD, there are calls for open-ended learning processes with active involvement of students in real-world processes. The study of Challenge Lab (Paper I) highlighted some key aspects when designing such learning environments that ‘remove unnecessary uncertainties’ while, in line with the reasoning by Bjork and Bjork (2011), ‘maintain desirable difficulties’.

Methodologically, this thesis contributes insights on how to evaluate transition initiatives that consider societal effects as well as the linking of effect to process. In

Paper II as well as in Paper III, we see the promise of realist evaluation (Pawson & Tilley, 1997) to guide future studies in relation to the questions asked in the field of sustainability transitions and learning, not least questions related to studies on the application of reflexive governance frameworks.

5.2 Implications for practice

Paper III presents a ‘lighthouse’ framework that may provide structure in conversations about desirable futures that are part of most backcasting processes. It seeks to approach sustainability in what we referred to as a ‘balanced approach’, meaning that the concept of sustainability is left open to invite for discussion, yet categories are provided to inspire and support the discussions.

The generative potential of backcasting implies that engagement with the process – where much is specified, pre-defined and controlled in terms of delivery, what is to be learnt etc. – may hinder its transformative potential. Consequently, facilitators should seek to create safe spaces (Senge, Hamilton, & Kania, 2015) for the process and specify enough structure to get started, but no more.

While the (theoretical) potential of backcasting arguably is about first articulating desirable futures (where to go and why) before identifying ways of attaining them (how), there seems to be a tendency in such processes to suggest solutions rather than to discuss questions related to what makes certain futures sustainable and desirable. The balancing of this tendency calls for careful scaffolding through skilful facilitation.

The design and setup of transition initiatives presented in Paper I and Paper II provide concrete examples of process designs in particular contexts. However, at this stage little can be said with more certainty about the conditions and mechanisms that make the process studied work (or not).

5.3 Limitations

Paper III seeks to provide a categorisation of central concepts present in sustainability discourse that are basic, sufficient, and non-overlapping. To be able to contribute something more concrete to the multi-faceted field of sustainability, it was in this particular study necessary to make a series of assumptions and choices. Accordingly, the lighthouse framework must be considered as a result from the methods applied in combination with these choices, where it is acknowledged that it represents one particular approach, among many, to sustainability.

Paper I and II represent case-based approaches, and I make no strong claims of generalizability beyond the cases studied in these papers. Rather, they are studies from a particular context valuable in their own right (Flyvbjerg, 2006). I plan to seek generalization on a level of generative mechanisms (Danermark et al., 2002) in the

two planned final studies towards my doctoral dissertation (see Future research), and I refer to the discussion and method chapters of these papers for more in-depth discussions on the limitations and reflections of the studies made.

Methodologically, there is potential to complement these case studies with further work on the conditions and mechanisms making these processes work and not work, hence opening up the ‘black box’ of process. Process is emphasised among the more prescriptive sustainability transition researchers, with several questions remaining to be answered, including the distinction between process and context, what it is that produce certain changes, and the role of process sequencing.

5.4 Future research

As argued in the introduction, the many designs and frameworks for engaging with sustainability transitions that prevail in literature seldom provide insights into the contingent nature of its application in its particular context, or the prior knowledge and beliefs of participating actors. The emphasis on evidence-based approaches is of little help for knowledge transfer if: (1) evidence is solely based on evaluation of outcomes and impacts from various approaches, (2) evidence is at best in relation to certain intents, and (3) the approach is not seeking attribution or explanation on the level of how and why particular effects were produced.

The future research avenues I have identified towards the doctoral thesis primarily relate to the underpinning of research and methodological development in critical realism. This metatheory will guide an in-depth evaluation and cross-case analysis to open up the ‘black box’ on a level of mechanisms that might explain what is actually ‘going on’ in the processes studied.

The focus on mechanisms seeks a form of causal explanation that is in contrast to the approach of causation that seeks regularity between events. Instead, mechanism understandings consider objects and social relations to have causal powers that may or may not produce regularities that can be observed. The focus of research is here on methods that establish the qualitative nature of such objects and what they are capable of doing (Sayer, 2002; Maxwell, 2004).

From the perspective of realist evaluation (Pawson & Tilley, 1997), one may start with the view that a certain backcasting process design represents a certain programme logic based on a set of intents. Yet, this design and traditional quantitative approaches to evaluation say little about how the process actually unfolds in reality – how it is experienced by participating actors. To mitigate this gap, realist evaluation focuses on how and why certain effects were produced by engaging with the following set of questions: what works, for whom, in what circumstances, in what respects, to what extent, and why? (ibid.). Studying the mechanisms behind such processes involves studying the interplay the resources

made available to people by the programme and the responses by people when engaging with those resources (Dalkin, Greenhalgh, Jones, Cunningham, & Lhussier, 2015).

Realist evaluation acknowledges that outcomes of interest (intended, unintended) are produced in context by certain mechanisms, so the focus of this kind of evaluation research is on so called context-mechanism-outcome (C-M-O) chains (Figure 4). While the design of a certain intervention is specific to each particular context, the mechanisms underlying a certain intervention may be generalizable across contexts, making it possible to transfer knowledge via mechanisms.

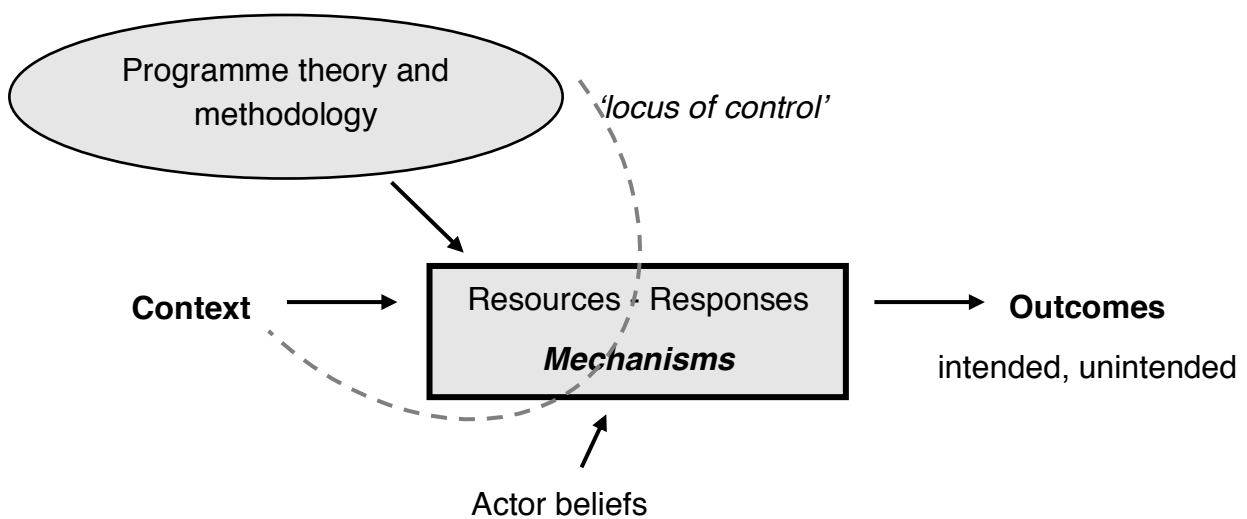


Figure 4 – Conceptual model representing primary interactions between programme theory (logic and design), actor beliefs, context, mechanisms and outcomes. The ‘locus’ refers to what programme designers typically can control (Programme theory and its translation into design with concrete resources made available to participating actors). N.b that the programme design may in itself take context and actor beliefs into consideration, and that outcomes of programmes may as well influence context and beliefs.

This view has important implications for practice. What ‘triggers’ a mechanism may differ between contexts and people, and programmes aiming for the same mechanisms may have different designs in different places (Pawson & Tilley, 1997), meaning that there can be no such thing as a universal ‘best practice’.

6 Conclusion

This chapter draws some conclusions on the completed research to date, and reconnects with the research aim and questions that were introduced in the first chapter of this thesis.

Contemporary sustainability challenges relate to unsustainabilities in present socio-technical systems, which in many respects demand innovation on a systems level (transitions) for becoming sustainable in time (Elzen et al., 2004; Grin et al., 2010; Markard et al., 2012). Transitional processes of change imply actor-interaction across societal sectors and perspectives (Geels, 2011). Due to their complex, uncertain and ambiguous nature, such processes are preferably supported by process-methodological approaches such as reflexive governance frameworks that emphasise collective experimentation and learning (Voss et al., 2006; Voss & Bornemann, 2011).

This thesis has studied the potential of and contributed towards the further development of backcasting from principles as a particular approach to guide sustainability transitions. It suggests backcasting from principles as complementary to mainstream logics of negotiating goals, targets, measurement, follow-up and implementation of decisions, with logics of open-ended search, exploration, experimentation and creation guided by explicit purpose and direction to navigate transitions into sustainable and desirable pathways (Holmberg & Larsson, 2018).

Backcasting starts with an articulation of desirable futures (Robinson et al., 2011) to provide purpose and direction of change, and was recently recommended by the Sustainable Development Solutions Network (SDSN, 2015) as an appropriate method to guide realisation of Agenda 2030 and the 17 Sustainable Development Goals. In backcasting, meaningful conversations on sustainable and desirable futures have been reasoned as key for successful collaboration with complex sustainability challenges. This thesis has suggested a 'lighthouse' framework (Paper III) for approaching sustainability in a way to support and inspire conversations on the concept that are both open and inviting for actors to construct meaning in their particular time and place, while also anchoring emergent understandings in key notions from sustainability discourses including aspects of social, ecological, economic, human needs and wellbeing.

Most reflexive governance approaches include futures envisioning, but the way the future is approached and articulated, and its eventual implications in such processes are underexplored (van der Helm, 2009). This thesis looked into the idea of articulating sustainable and desirable futures on a level of principles, and subjected those ideas to empirical examination. Capabilities of (a set of) sustainability principles were reasoned to support thinking that goes beyond what currently is, that

Conclusion

is broad, and is together for shared meaning and understanding. These capabilities are suggested as a set of hypotheses for further inquiry (Paper II).

The concrete cases studied in this thesis provide insights into backcasting from principles processes, including design characteristics, how they unfold, and process outcomes. Such processes have been studied in two contexts: (1) an arena creating space for students to lead sustainability transitions, and (2) in a regional multi-stakeholder process related to climate policy. These studies represent initial attempts to better understand conditions and mechanisms into the kinds of learning that occur in these spaces, in particular in relation to Education for Sustainable Development and (transformative) social learning. In contributing to my doctoral thesis, these studies will be complemented with in-depth procedures drawing from realist evaluation (Pawson & Tilley, 1997), including cross-case analysis to ease the distinguishing of process from context.

References

- Armitage, D., Marschke, M., & Plummer, R. (2008). Adaptive co-management and the paradox of learning. *Global Environmental Change*, 18(1), 86–98. <https://doi.org/10.1016/j.gloenvcha.2007.07.002>
- Aronson, J. (1995). A pragmatic view of thematic analysis. *The Qualitative Report*, 2(1), 1–3.
- Ascher, W. (1979). Problems of Forecasting and Technology Assessment. *Technological Forecasting and Social Change*, 13, 149–156.
- Bai, X., van der Leeuw, S., O'Brien, K., Berkhout, F., Biermann, F., Brondizio, E. S., ... Syvitski, J. (2016). Plausible and desirable futures in the Anthropocene: A new research agenda. *Global Environmental Change*, 39, 351–362. <https://doi.org/10.1016/j.gloenvcha.2015.09.017>
- Barth, M., & Michelsen, G. (2013). Learning for change: an educational contribution to sustainability science. *Sustainability Science*, 8(1), 103–119. <https://doi.org/10.1007/s11625-012-0181-5>
- Basse, M. (1999). *Case study research in educational settings*. Buckingham: Open University Press.
- Bauman, Z. (2000). *Liquid modernity*. Cambridge, UK : Malden, MA: Polity Press ; Blackwell.
- Beers, P. J., Mierlo, B. van, & Hoes, A.-C. (2016). Toward an Integrative Perspective on Social Learning in System Innovation Initiatives. *Ecology and Society*, 21(1). <https://doi.org/10.5751/ES-08148-210133>
- Bhaskar, R. (2008). *A realist theory of science*. Abingdon, Oxon and New York, NY: Routledge.
- Bjork, E. L., & Bjork, R. A. (2011). Making things hard on yourself, but in a good way: Creating desirable difficulties to enhance learning. *Psychology and the Real World: Essays Illustrating Fundamental Contributions to Society*, 2, 59–68.
- Bos, J. J., Brown, R. R., & Farrelly, M. A. (2013). A design framework for creating social learning situations. *Global Environmental Change*, 23(2), 398–412. <https://doi.org/10.1016/j.gloenvcha.2012.12.003>
- Boulding, K. E. (1966). The economics of the coming spaceship earth. *Environmental Quality Issues in a Growing Economy*.
- Brandt, P., Ernst, A., Gralla, F., Luederitz, C., Lang, D. J., Newig, J., ... von Wehrden, H. (2013). A review of transdisciplinary research in sustainability science. *Ecological Economics*, 92, 1–15. <https://doi.org/10.1016/j.ecolecon.2013.04.008>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Broman, G. I., & Robèrt, K.-H. (2017). A framework for strategic sustainable development. *Journal of Cleaner Production*, 140, 17–31. <https://doi.org/10.1016/j.jclepro.2015.10.121>

References

- Bryman, A. (2012). *Social research methods* (4th ed). Oxford ; New York: Oxford University Press.
- Budwig, N. (2015). Concepts and tools from the learning sciences for linking research, teaching and practice around sustainability issues. *Current Opinion in Environmental Sustainability*, 16, 99–104. <https://doi.org/10.1016/j.cosust.2015.08.003>
- Caniglia, G., Schöpke, N., Lang, D. J., Abson, D. J., Luederitz, C., Wiek, A., ... von Wehrden, H. (2017). Experiments and evidence in sustainability science: A typology. *Journal of Cleaner Production*, 169, 39–47. <https://doi.org/10.1016/j.jclepro.2017.05.164>
- Cortese, A. D. (2003). The critical role of higher education in creating a sustainable future. *Planning for Higher Education*, 31(3), 15–22.
- Crutzen, P. J. (2002). Geology of mankind. *Nature*, 415, 1.
- Dalkin, S. M., Greenhalgh, J., Jones, D., Cunningham, B., & Lhussier, M. (2015). What's in a mechanism? Development of a key concept in realist evaluation. *Implementation Science*, 10(1). <https://doi.org/10.1186/s13012-015-0237-x>
- Daly, H. E. (1973). *Toward a Steady-State Economy*. San Francisco: W. H. Freeman and Company.
- Danermark, B., Ekström, M., Jakobsen, L., & Karlsson, J. C. (2002). *Explaining society: an Introduction to critical realism in the social sciences*. Hoboken: Taylor and Francis. Retrieved from <http://public.eblib.com/choice/publicfullrecord.aspx?p=240636>
- Dreborg, K. H. (1996). Essence of backcasting. *Futures*, 28(9), 813–828.
- Elzen, B., Geels, F. W., & Green, K. (2004). *System Innovation and the Transition to Sustainability: Theory, Evidence and Policy*. Northampton, MA, USA: Edward Elgar Publishing.
- Elzen, B., & Wieczorek, A. (2005). Transitions towards sustainability through system innovation. *Technological Forecasting and Social Change*, 72(6), 651–661. <https://doi.org/10.1016/j.techfore.2005.04.002>
- Engeström, Y. (1987). *Learning by expanding: an activity-theoretical approach to developmental research*. Helsinki: Orienta-Konsultit.
- Engeström, Y. (2016). *Studies in Expansive Learning: Learning what is not yet there*. Cambridge: Cambridge University Press.
- Engeström, Y., & Sannino, A. (2010). Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review*, 5(1), 1–24. <https://doi.org/10.1016/j.edurev.2009.12.002>
- European Environment Agency. (2017). *Perspectives on transitions to sustainability* (No. 25/2017). Luxembourg.
- Fazey, I., Schöpke, N., Caniglia, G., Patterson, J., Hultman, J., van Mierlo, B., ... Wyborn, C. (2018). Ten essentials for action-oriented and second order energy transitions, transformations and climate change research. *Energy Research & Social Science*, 40, 54–70. <https://doi.org/10.1016/j.erss.2017.11.026>

References

- Feola, G. (2015). Societal transformation in response to global environmental change: A review of emerging concepts. *Ambio*, 44(5), 376–390. <https://doi.org/10.1007/s13280-014-0582-z>
- Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, 12(2), 219–245. <https://doi.org/10.1177/1077800405284363>
- Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive Governance of Social-Ecological systems. *Annual Review of Environment and Resources*, 30.
- Forrest, N., & Wiek, A. (2014). Learning from success—Toward evidence-informed sustainability transitions in communities. *Environmental Innovation and Societal Transitions*, 12, 66–88. <https://doi.org/10.1016/j.eist.2014.01.003>
- Funtowicz, S. O., & Ravetz, J. R. (1993). Science for the post-normal age. *Futures*, 31(7), 735–755.
- Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*, 31(8), 1257–1274.
- Geels, F. W. (2005). Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. *Technological Forecasting and Social Change*, 72(6), 681–696. <https://doi.org/10.1016/j.techfore.2004.08.014>
- Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, 1(1), 24–40. <https://doi.org/10.1016/j.eist.2011.02.002>
- Geels, F. W., Berkhout, F., & van Vuuren, D. P. (2016). Bridging analytical approaches for low-carbon transitions. *Nature Climate Change*, 6(6), 576–583. <https://doi.org/10.1038/nclimate2980>
- Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge: The dynamics of science and research in contemporary societies*. London: Sage Publications.
- Giddens, A. (2009). *The Politics of Climate Change*. Cambridge, UK: Polity Press.
- Grin, J., Rotmans, J., & Schot, J. W. (2010). *Transitions to sustainable development: new directions in the study of long term transformative change*. New York: Routledge.
- Hirsch Hadorn, G. (Ed.). (2008). *Handbook of transdisciplinary research*. Dordrecht ; London: Springer.
- Holmberg, J. (1995). *Socio-Ecological Principles and Indicators for Sustainability* (Thesis for the Degree of Doctor of Philosophy). Chalmers University of Technology, Gothenburg, Sweden.
- Holmberg, J. (1998). Backcasting: A Natural Step in Operationalising Sustainable Development. *Greener Management International*, 23, 30–51.
- Holmberg, J. (2014). Transformative learning and leadership for a sustainable future: Challenge Lab at Chalmers University of Technology. In P. B. Corcoran, B. P. Hollingshead, H. Lotz-Sisitka, A. E. J. Wals, & J. P. Weakland (Eds.), *Intergenerational learning and transformative leadership for sustainable futures* (pp. 91–102). The Netherlands: Wageningen Academic Publishers. Retrieved from http://www.wageningenacademic.com/doi/pdf/10.3920/978-90-8686-802-5_4

References

- Holmberg, J., & Larsson, J. (2018). A Sustainability Lighthouse—Supporting Transition Leadership and Conversations on Desirable Futures. *Sustainability*, *10*(11), 3842. <https://doi.org/10.3390/su10113842>
- Holmberg, J., & Robèrt, K.-H. (2000). Backcasting from non-overlapping sustainability principles - a framework for strategic planning. *International Journal of Sustainable Development and World Ecology*, *7*, 291–308.
- Hölscher, K., Wittmayer, J. M., & Loorbach, D. (2018). Transition versus transformation: What's the difference? *Environmental Innovation and Societal Transitions*, *27*, 1–3. <https://doi.org/10.1016/j.eist.2017.10.007>
- Hopwood, B., Mellor, M., & O'Brien, G. (2005). Sustainable development: mapping different approaches. *Sustainable Development*, *13*(1), 38–52. <https://doi.org/10.1002/sd.244>
- Jacobs, M. (1999). Sustainable development as a contested concept. In A. Dobson, *Fairness and Futurity: Essays on Environmental Sustainability and Social Justice* (pp. 21–45). Oxford: Oxford University Press.
- Kates, R. W., Clark, W. C., Corell, R. J., & et al. (2001). Sustainability Science. *Science*, *292*(5517), 641–642.
- Klein, J. T., Grossenbacher-Mansuy, W., Häberli, R., Bill, A., Scholz, R. W., & Welti, M. (Eds.). (2001). *Transdisciplinarity: Joint Problem Solving among Science, Technology, and Society. An Effective Way for Managing Complexity*. Basel: Birkhäuser Basel. https://doi.org/10.1007/978-3-0348-8419-8_2
- Kuhn, T. S. (1970). Revolutions as Changes of World View. In *The Structure of Scientific Revolutions* (2nd ed.). University of Chicago Press.
- Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., ... Thomas, C. J. (2012). Transdisciplinary research in sustainability science: practice, principles, and challenges. *Sustainability Science*, *7*(S1), 25–43. <https://doi.org/10.1007/s11625-011-0149-x>
- Larsson, J., & Holmberg, J. (2018). Learning while creating value for sustainability transitions: The case of Challenge Lab at Chalmers University of Technology. *Journal of Cleaner Production*, *172*, 4411–4420. <https://doi.org/10.1016/j.jclepro.2017.03.072>
- Larsson, J., & Holmberg, J. (2019). Sustainability principles in guiding transitions: exploring capabilities through a regional backcasting case. *Draft Manuscript*.
- Lave, J. (1991). Situating learning in communities of practice. *Perspectives on Socially Shared Cognition*, *2*, 63–82.
- Loorbach. (2014). To Transition! Governance Penarchy in the New Transformation Prof. dr. Derk Loorbach, October, 31, 2014 Erasmus University Rotterdam 978-90-822881-0-0. Retrieved from https://www.drift.eur.nl/wp-content/uploads/2014/11/To_Transition-Loorbach-2014.pdf
- Loorbach, D. (2007). *Transition management: new mode of governance for sustainable development = Transitiemanagement: nieuwe vorm van governance voor duurzame ontwikkeling*. Utrecht: Internat. Books.

References

- Loorbach, D. (2010). Transition management for sustainable development: a prescriptive, complexity-based governance framework. *Governance*, 23(1), 161–183.
- Loorbach, D., Frantzeskaki, N., & Avelino, F. (2017). Sustainability transitions research: Transforming science and practice for societal change. *Annual Review of Environment and Resources*, 42.
- Loorbach, D., & Rotmans, J. (2010). The practice of transition management: Examples and lessons from four distinct cases. *Futures*, 42(3), 237–246. <https://doi.org/10.1016/j.futures.2009.11.009>
- Lotz-Sisitka, H., Ali, M. B., Mphepo, G., Chaves, M., Macintyre, T., Pesanayi, T., ... McGarry, D. (2016). Co-designing research on transgressive learning in times of climate change. *Current Opinion in Environmental Sustainability*, 20, 50–55. <https://doi.org/10.1016/j.cosust.2016.04.004>
- Lotz-Sisitka, H., Wals, A. E., Kronlid, D., & McGarry, D. (2015). Transformative, transgressive social learning: rethinking higher education pedagogy in times of systemic global dysfunction. *Current Opinion in Environmental Sustainability*, 16, 73–80. <https://doi.org/10.1016/j.cosust.2015.07.018>
- Lozano, R. (2006). Incorporation and institutionalization of SD into universities: breaking through barriers to change. *Journal of Cleaner Production*, 14(9–11), 787–796. <https://doi.org/10.1016/j.jclepro.2005.12.010>
- Macintyre, T., Lotz-Sisitka, H., Wals, A., Vogel, C., & Tassone, V. (2018). Towards transformative social learning on the path to 1.5 degrees. *Current Opinion in Environmental Sustainability*, 31, 80–87. <https://doi.org/10.1016/j.cosust.2017.12.003>
- March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, 2(1), 71–87.
- Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, 41(6), 955–967. <https://doi.org/10.1016/j.respol.2012.02.013>
- Maxwell, J. A. (2004). Causal explanation, qualitative research, and scientific inquiry in education. *Educational Researcher*, 33(2), 3–11.
- Meadowcroft, J. (2009). What about the politics? Sustainable development, transition management, and long term energy transitions. *Policy Sciences*, 42(4), 323–340. <https://doi.org/10.1007/s11077-009-9097-z>
- Meadows, D. H., Meadows, D. L., Randers, J., & Behrens, W. W. (1972). *The limits to growth*. New York.
- Mendelsohn, E. (1977). The Social Construction of Scientific Knowledge. In E. Mendelsohn, P. Weingart, & R. Whitley (Eds.), *The Social Production of Scientific Knowledge* (Vol. 1, pp. 3–25). Dordrecht, Holland and Boston, USA: D. Reidel Publishing Company.
- Merriam, S. B. (1998). *Qualitative Research and Case Study Applications in Education. Revised and Expanded from 'Case Study Research in Education'*. 350 Sansome St, San Francisco, CA 94104: Jossey-Bass Publishers.

References

- Miller, T. R. (2013). Constructing sustainability science: emerging perspectives and research trajectories. *Sustainability Science*, 8(2), 279–293. <https://doi.org/10.1007/s11625-012-0180-6>
- Olsson, P., Gunderson, L. H., Carpenter, S. R., Ryan, P., Lebel, L., Folke, C., & Holling, C. S. (2006). Shooting the Rapids: Navigating Transitions to Adaptive Governance of Social-Ecological Systems. *Ecology and Society*, 11(1). <https://doi.org/10.5751/ES-01595-110118>
- Pahl-Wostl, C. (2009). A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change*, 19(3), 354–365. <https://doi.org/10.1016/j.gloenvcha.2009.06.001>
- Patton, M. Q. (1990). *Qualitative evaluation and research methods* (2nd ed.). Thousand Oaks, CA: Sage Publications.
- Patton, M. Q. (2017). Principles-focused evaluation. *New York, NY: Guilford*.
- Pawson, R., & Tilley, N. (1997). *Realistic evaluation*. London, California and New Delhi: Sage.
- Popper, K. R. (1972). Appendix: The Bucket and the Searchlight: Two Theories of Knowledge. In *Objective Knowledge. An Evolutionary Approach* (pp. 341–361). Oxford: Clarendon Press.
- Quist, J., Wittmayer, J., Van Steenbergen, F., & Loorbach, D. (2013). Combining backcasting and transition management in the community arena. In *Proceedings of SCORAI Europe & InContext Workshop, Rotterdam, The Netherlands, 7-8 October 2013; Sustainable Consumption Transitions Series, Issue 3*. Retrieved from <http://repository.tudelft.nl/view/ir/uuid:abde24ee-a1c4-4a9b-929c-9d5c48f4fb36/>
- Raworth, K. (2012). A safe and just space for humanity: can we live within the doughnut. *Oxfam Policy and Practice: Climate Change and Resilience*, 8(1), 1–26.
- Reed, M., Evely, A. C., Cundill, G., Fazey, I. R. A., Glass, J., Laing, A., ... others. (2010). What is social learning? *Ecology and Society*. Retrieved from <https://research-repository.st-andrews.ac.uk/handle/10023/1624>
- Ringland, G. (2002). *Scenarios in Business*. Chichester, UK: Wiley.
- Rittel, H. W., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4(2), 155–169.
- Robinson, J. (1988). Unlearning and backcasting. *Technological Forecasting and Social Change*, 39(5), 325–338.
- Robinson, J. (1990). Future under glass - A recipe for people who hate to predict. *Futures*, 22(8), 820–842.
- Robinson, J. (2003). Future subjunctive: backcasting as social learning. *Futures*, 35(8), 839–856. [https://doi.org/10.1016/S0016-3287\(03\)00039-9](https://doi.org/10.1016/S0016-3287(03)00039-9)
- Robinson, J. (2004). Squaring the circle? Some thoughts on the idea of sustainable development. *Ecological Economics*, 48(4), 369–384. <https://doi.org/10.1016/j.ecolecon.2003.10.017>
- Robinson, J., Burch, S., Talwar, S., O'Shea, M., & Walsh, M. (2011). Envisioning sustainability: Recent progress in the use of participatory backcasting approaches

References

- for sustainability research. *Technological Forecasting and Social Change*, 78(5), 756–768. <https://doi.org/10.1016/j.techfore.2010.12.006>
- Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin, F. S., Lambin, E. F., ... others. (2009). A safe operating space for humanity. *Nature*, 461(7263), 472–475.
- Rosch, E. (1988). Principles of Categorization. In *Readings in Cognitive Science* (pp. 312–322). Elsevier. <https://doi.org/10.1016/B978-1-4832-1446-7.50028-5>
- Rotmans, J., Kemp, R., & van Asselt, M. (2001). More evolution than revolution: transition management in public policy. *Foresight*, 3(1), 15–31. <https://doi.org/10.1108/14636680110803003>
- Rotmans, J., & Loorbach, D. (2008). Transition management: Reflexive governance of societal complexity through searching, learning and experimenting. In J. C. J. M. van den Bergh & F. R. Bruinsma (Eds.), *Managing the transition to renewable energy: Theory and practice from local, regional and macro perspectives* (pp. 15–46). Cheltenham: Edward Elgar.
- Sayer, A. (2002). *Method in Social Science: Revised 2nd Edition*. S.L.: Routledge.
- Schäpke, N. (2018). *Linking Transitions to Sustainability: Individual Agency, Normativity and Transdisciplinary Collaborations in Transition Management* (Thesis for the Degree of Doctor of Philosophy). Leuphana University of Luneburg, Institute for Ethics and Transdisciplinary Sustainability Research.
- Scholz, R. W. (2017). The Normative Dimension in Transdisciplinarity, Transition Management, and Transformation Sciences: New Roles of Science and Universities in Sustainable Transitioning. *Sustainability*, 9(6), 991. <https://doi.org/10.3390/su9060991>
- Schot, J., & Geels, F. W. (2008). Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. *Technology Analysis & Strategic Management*, 20(5), 537–554. <https://doi.org/10.1080/09537320802292651>
- SDSN. (2015). *Getting Started with the Sustainable Development Goals - A Guide for Stakeholders*. Retrieved from <https://sdg.guide/>
- Sen, A. (2013). The Ends and Means of Sustainability. *Journal of Human Development and Capabilities*, 14(1), 6–20. <https://doi.org/10.1080/19452829.2012.747492>
- Senge, P., Hamilton, H., & Kania, J. (2015). The dawn of system leadership. *Stanford Social Innovation Review Winter, 2015*, 27–33.
- Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher*, 27(2), 4–13.
- Sharpe, B., Hodgson, A., Leicester, G., Lyon, A., & Fazey, I. (2016). Three horizons: a pathways practice for transformation. *Ecology and Society*, 21(2). <https://doi.org/10.5751/ES-08388-210247>
- Shove, E., & Walker, G. (2007). CAUTION! Transitions ahead: politics, practice, and sustainable transition management. *Environment and Planning A*, 39(4), 763–770. <https://doi.org/10.1068/a39310>

References

- Smith, A., Stirling, A., & Berkhout, F. (2005). The governance of sustainable socio-technical transitions. *Research Policy*, 34(10), 1491–1510. <https://doi.org/10.1016/j.respol.2005.07.005>
- Smith, A., Voß, J.-P., & Grin, J. (2010). Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy*, 39(4), 435–448. <https://doi.org/10.1016/j.respol.2010.01.023>
- Sneddon, C., Howarth, R. B., & Norgaard, R. B. (2006). Sustainable development in a post-Brundtland world. *Ecological Economics*, 57(2), 253–268. <https://doi.org/10.1016/j.ecolecon.2005.04.013>
- Stake, R. E. (1995). *The Art of Case Study Research*. London: Sage.
- Steffen, W., Persson, Å., Deutsch, L., Zalasiewicz, J., Williams, M., Richardson, K., ... Svedin, U. (2011). The Anthropocene: From Global Change to Planetary Stewardship. *AMBIO*, 40(7), 739–761. <https://doi.org/10.1007/s13280-011-0185-x>
- Sterling, S. (2011). Transformative learning and sustainability: Sketching the conceptual ground. *Learning and Teaching in Higher Education*, 5(11), 17–33.
- STRN. (2017). *A research agenda for the Sustainability Transitions Research Network*.
- Swilling, M., & Annecke, E. (2012). *Just transitions: explorations of sustainability in an unfair world*. Claremont: UCT-Press.
- Talwar, S., Wiek, A., & Robinson, J. (2011). User engagement in sustainability research. *Science and Public Policy*, 38(5), 379–390.
- Tilbury, D. (2011). *Education for sustainable development - An Expert Review of Processes and Learning*. Paris, France: UNESCO.
- Tilbury, D. (2016). Student Engagement and Leadership in Higher Education for Sustainability. In M. Barth, G. Michelsen, M. Rieckmann, & I. Thomas (Eds.), *Routledge Handbook of Higher Education for Sustainable Development* (pp. 273–286). New York: Routledge.
- UNCED. (1992). The Rio Declaration on Environment and Development. Presented at the The United Nations Conference on Environment and Development, Rio de Janeiro 3-14 June 1992, New York: United Nations.
- UNEP. (1972). *Stockholm declaration of the United Nations Conference on the Human Environment*. United Nations Environmental Program.
- UNESCO. (2014). *Shaping the Future We Want: UN Decade of Education for Sustainable Development (2005-2014) : Final Report*. Paris, France.
- UNFCCC. (2015). *Adoption of the Paris Agreement*. Geneva, Switzerland: United Nations.
- United Nations. (2002). *Report of the World Summit on Sustainable Development: Johannesburg, South Africa, 26 August-4 September 2002*. New York: United Nations.
- United Nations. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. New York: United Nations.
- van de Kerkhof, M., & Wiczorek, A. (2005). Learning and stakeholder participation in transition processes towards sustainability: Methodological considerations.

References

- Technological Forecasting and Social Change*, 72(6), 733–747.
<https://doi.org/10.1016/j.techfore.2004.10.002>
- van der Helm, R. (2009). The vision phenomenon: Towards a theoretical underpinning of visions of the future and the process of envisioning. *Futures*, 41(2), 96–104.
<https://doi.org/10.1016/j.futures.2008.07.036>
- Van Poeck, K., Östman, L., & Block, T. (2018). Opening up the black box of learning-by-doing in sustainability transitions. *Environmental Innovation and Societal Transitions*. <https://doi.org/10.1016/j.eist.2018.12.006>
- Vare, P., & Scott, W. (2007). Learning for a Change: Exploring the Relationship Between Education and Sustainable Development. *Journal of Education for Sustainable Development*, 1(2), 191–198. <https://doi.org/10.1177/097340820700100209>
- Vergragt, P. J., & Quist, J. (2011). Backcasting for sustainability: Introduction to the special issue. *Technological Forecasting and Social Change*, 78(5), 747–755.
<https://doi.org/10.1016/j.techfore.2011.03.010>
- Voss, J.-P., Bauknecht, D., & Kemp, R. (Eds.). (2006). *Reflexive governance for sustainable development*. Cheltenham, Glos, UK ; Northampton, MA: Edward Elgar.
- Voss, J.-P., & Bornemann, B. (2011). The politics of reflexive governance: challenges for designing adaptive management and transition management. *Ecology and Society*, 16(2). Retrieved from <http://www.ecologyandsociety.org/vol16/iss2/art9/main.html>
- Waas, T., Hugé, J., Verbruggen, A., & Wright, T. (2011). Sustainable Development: A Bird's Eye View. *Sustainability*, 3(12), 1637–1661.
<https://doi.org/10.3390/su3101637>
- Wackernagel, M., & Rees, W. (1998). *Our ecological footprint: reducing human impact on the earth* (Vol. 9). New Society Publishers.
- Wals, A. E. J. (Ed.). (2009). *Social learning towards a sustainable world: Principles, perspectives, and praxis*. The Netherlands: Wageningen Academic Publishers. Retrieved from <http://www.wageningenacademic.com/doi/book/10.3920/978-90-8686-594-9>
- Wals, A. E. J., & Jickling, B. (2002). “Sustainability” in higher education: From doublethink and newspeak to critical thinking and meaningful learning. *International Journal of Sustainability in Higher Education*, 3(3), 221–232.
<https://doi.org/10.1108/14676370210434688>
- Walter, A. I., Helgenberger, S., Wiek, A., & Scholz, R. W. (2007). Measuring societal effects of transdisciplinary research projects: Design and application of an evaluation method. *Evaluation and Program Planning*, 30(4), 325–338.
<https://doi.org/10.1016/j.evalprogplan.2007.08.002>
- WCED. (1987). *Report of the World Commission on Environment and Development: Our Common Future*. Oslo: United Nations.
- Wenger, E. (1998). *Communities of Practice: Learning, Meaning, and Identity*. United Kingdom: Cambridge University Press.

References

- Wiek, A., Talwar, S., O'Shea, M., & Robinson, J. (2014). Toward a methodological scheme for capturing societal effects of participatory sustainability research. *Research Evaluation*, 23(2), 117–132. <https://doi.org/10.1093/reseval/rvt031>