Chapter 3
Transformational Sustainability Research Methodology

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Abstract Sustainability science can roughly be differentiated into two distinct research streams – a "descriptive-analytical" and a "transformational" one. While the former is primarily concerned with describing and analyzing sustainability problems, the latter aims at developing evidence-supported solution options to solve these problems. This chapter presents relevant methodological guidelines and requirements as well as five exemplary research frameworks for transformational sustainability research. The frameworks are for (1) complex problem-handling, (2) transition management and governance, (3) backcasting, (4) integrated planning research, and (5) the transformational sustainability research (TRANSFORM framework). The TRANSFORM framework aims at synthesizing key components of the other frameworks. The frameworks provide guidelines for transformational sustainability research; yet, willingness and capacity of academic, governmental, private, and nonprofit organizations to use them for knowledge-generating operations are still fairly low. To truly support sustainability transformations, much more of this solution-oriented sustainability research is needed.

Keywords Descriptive-analytical sustainability research • Transformational sustainability research • Knowledge types • Methodological frameworks • Evidence-supported solution options

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1 Descriptive-Analytical vs. Transformational Sustainability Research

Sustainability research addresses problems that pose major threats to the viability and integrity of societies around the world (Kates et al. 2001; Clark and Dickson 2003; Jerneck et al. 2011; Sarewitz et al. 2012; Miller et al. 2014). Yet, the term "addresses" is ambiguous, which is why the field of sustainability science has mainly developed in two distinctive streams (Wiek et al. 2012).

The first one is primarily concerned with addressing sustainability problems through describing and analyzing them—their complexity, dynamics, and cause-effect relations (Turner et al. 2003; Ostrom 2009; Collins et al. 2011; De Vries 2013). The dominant methodological approach here is systems thinking and modeling, applied to past, current, and future sustainability problems. According to its main features, this stream has been called the "descriptive-analytical."

The second stream addresses sustainability problems by developing evidence-supported solution options for them (Sarewitz et al. 2012; Miller et al. 2014; Wiek et al. 2015). In this context, solutions are real-world changes that depend on actions executed by stakeholders other than researchers. Solution options, by contrast, are evidence-supported, actionable *knowledge* that, if applied, can *lead* to such real-world changes toward sustainability. Solutions to sustainability problems are generally *not* simple technical fixes or command-control procedures; they are often as complex as the problems themselves and require long-term processes that involve real-world experimentation, collective learning, and continuous adaptation. The second stream is therefore primarily concerned with providing evidence for how successfully to intervene in sustainability problems in order to resolve or at least mitigate them. For this, a sufficient problem understanding is advantageous; yet, gaining this understanding is here undertaken pragmatically, without losing sight of the ultimate objective to develop evidence-supported solution options (Sarewitz et al. 2012). With its intention to transform problems toward solutions, this stream has been called the "transformational."

The fact that a solution-oriented perspective is distinctly different from a problem-focused one has been acknowledged in several fields over the past decade. As Robinson and Sirard (2005, p. 196) point out for the field of public health research, "Knowing a cause of a problem, while sometimes a helpful first step, does not directly translate into knowing how to intervene to solve that problem." Let's illustrate the difference between descriptive-analytical and transformational sustainability research with examples from climate change research. A great deal of research in this area addresses emission sources, pathways, atmospheric CO_2 concentrations, temperature changes, and effects such as sea-level rise, as well as impacts on societies, for example, migration from coastal regions. This research enhances our understanding of the complex cause-effect relations in the human-climate system. However, it does not provide any knowledge as to what we can *do* in order to mitigate or adapt to climate change effectively. The latter is being pursued in transformational climate change research. Here, researchers develop and

test different strategies that can *change* the current emission sources, pathways, atmospheric CO_2 concentrations, temperature changes, effects, and impacts toward a sustainable vision.

For *transformational* sustainability research, which is the focus of this chapter, it is important to develop clear methodological guidelines (as it is important for any other field). Such guidelines provide researchers with instructions and quality criteria on how to conduct transformational sustainability research. They enable researchers to select, combine, and apply methods in pursuit of designing and testing solution options. While such guidelines might be informed by existing methodologies, we cannot simply carry over methodologies of established disciplines and hope to accomplish transformational results with approaches that were not built for this purpose. If transformational solutions are the ultimate goal, we need to develop and adopt research methodologies that are capable of reaching this goal (Miller et al. 2014).

Three general methodological requirements apply to transformational sustainability research: first, transformational research needs to apply *suitable methods*; such methods are transparent, structured, and replicable sequences of steps that generate knowledge *as ingredients of* solution options. Such solution options should be composed of different types of knowledge (Grunwald 2007): they should (1) be based on, at least, a sufficient understanding of the problem (descriptive-analytical/system knowledge); (2) be guided by a coherent and sustainability-inspired vision (normative/target knowledge); and (3) outline concrete transition and intervention strategies, i.e., action plans that detail how to resolve the problem and reach the vision (instructional/transformation knowledge). Thus, second, transformational sustainability research needs to employ *methodological frameworks* that combine different types of methods to generate such multifaceted actionable knowledge. And, third, transformational sustainability research is concerned with real-world problems and aims at actionable knowledge that stakeholders are willing and able to implement. Therefore, there is broad agreement that such research has to be carried out in *close collaboration* between scientists and nonacademic stakeholders from business, government, and civil society (Clark and Dickson 2003; Talwar et al. 2011; Lang et al. 2012). As recent reviews have addressed the third requirement (e.g., Spangenberg 2011; Lang et al. 2012), this chapter focuses on the first two requirements.

The terms "research" and "research methodology" often refer to advanced academic research. Yet, we use these terms here in a much broader sense, referring to a particular type of knowledge generation that also includes student research and research conducted by professionals. The key condition is that the respective research activity adheres to quality criteria, including validity, reliability, saliency, and so forth; these criteria need to be adapted to the specific objectives of transformational sustainability research. While transformational sustainability research can draw on a spectrum of suitable methodological frameworks (e.g., Kajikawa 2008; Jerneck et al. 2011; Wiek et al. 2012), it is important to understand the similarities and differences among them. This enables students, researchers, and professionals to tailor the transformational research methodology to the specific objectives and needs of their respective projects.

- **Task**: *Illustrate for a research area related to sustainability challenges other than climate change research (e.g., urbanization, food provision, public health) the difference between the descriptive-analytical and the transformational stream in sustainability science. Try to formulate research questions for both streams.*

2 Methodological Frameworks for Transformational Sustainability Research

Several suitable methodological frameworks have been developed and applied that combine different methods in a meaningful sequence in order to generate actionable knowledge or, in other words, evidence-supported solution options for sustainability challenges. For pragmatic reasons, we present only *basic framework types* here and neglect all frameworks that are based on minor variations of framework elements.[1]

We first describe four prominent methodological frameworks that have been widely applied in sustainability projects. They all fulfill, to varying degrees, the following requirements of methodological frameworks for transformational sustainability research (a subset of the first two requirements outlined above): (1) they allow for addressing "wicked" problems similar to sustainability problems; (2) they combine methods in a way that generates solution options; and (3) they provide empirical evidence for the effectiveness of the solution options generated. In the descriptions below, we refer back to these requirements. The sequence of steps the respective framework proposes is indicated in Table 3.1. For this, we differentiate three families of procedures and methods, corresponding to the three knowledge types mentioned above. First, procedures and methods that produce descriptive-analytical or system knowledge offer insights on the past, current, or future state of the problem addressed. This *descriptive-analytical family* includes, for example, methods for systems modeling and scenario analysis (Ostrom 2009). Second, procedures and methods that produce normative or target knowledge offer insights on the (un)sustainability of past, current, or future states of the problem. This *normative family* includes, for example, methods for assessment and visioning (Swart et al. 2004; Wiek and Iwaniec 2014). Third, procedures and methods that produce instructional or transformation knowledge offer insights on how to resolve the problem and achieve the sustainable vision. This *instructional family* includes, for example, intervention research methods (Fraser et al. 2009). Evaluating the impact of interventions draws from methods in the descriptive-analytical and the normative method families.

[1] The literature uses the terms "framework", "method", "approach", and "tool" sometimes interchangeably, sometimes as distinctly different (not consistently). There is no need to differentiate between these terms here. We focus on frameworks as defined above, irrespective of the fact that some of the frameworks are labeled, for instance, as "methods" (e.g., complex problem-handling) or "approaches" (e.g., backcasting).

Table 3.1 Overview of four methodological frameworks for transformational sustainability research.

	Complex Problem Handling	*Transition Management and Governance*	*Backcasting*	*Transdisciplinary Case Study*
Step 1	Problem analysis	Problem analysis	Envisioning normative scenarios	System analysis
Step 2	Goal setting	Constructing sustainable vision	Current state analysis & appraisal	Scenario construction
Step 3	Intervention design, analysis, selection	Transition strategy design	Backcasting pathways	Multi-criteria assessment (current state and scenarios)
Step 4	Implementation	Transition experiments		Strategy derivation
Step 5	Intervention evaluation	Evaluation		
Step 6		Multiplication		

The text of those steps that are dominated by activities other than research is shaded in gray; the steps mainly using methods of the descriptive-analytical family are shaded in light gray, those using mainly methods of the normative family in dark gray, and those mainly using methods of the instructional family in black

The first framework is the *complex problem-handling* framework developed beginning in the early 1990s by Dorien DeTombe (2001). This framework addresses complex societal problems that are similar to sustainability problems, as they display dynamic features, include many phenomena, involve many actors, and have severe impacts on society. The approach is solution oriented and encompasses all phases of problem handling, from building awareness of the problem to evaluating interventions. The complex problem-handling framework has been applied to a variety of complex societal problems ranging from climate change to children born of war (DeTombe 2008; Mochmann and DeTombe 2010). What types of methods are being adopted and how they are sequentially combined in the complex problem-handling framework is indicated in Table 3.1. The complex problem-handling framework focuses on the problem to be resolved. While goals are recognized as additional points of reference, the main emphasis is put on the problem analysis and the intervention analysis, each with several sub-steps. However, there is a lack of actual provision of solution options and subsequent implementations (with impact on the real world). The framework's focus on the problem and the intervention is shared, for instance, with the *intervention research* framework (Fraser et al. 2009), with even more emphasis put on the elaboration of intervention options. While the complex problem-handling framework lacks the step of empirically following through to the evaluation stage (no evaluative impact studies have been conducted so far, to our knowledge), the intervention research framework has a strong track record in intervention testing. However, intervention research does not always tackle problems as complex as sustainability problems.

The second framework is the *transition management and governance* approach developed beginning in the early 2000s by Jan Rotmans, Derk Loorbach, and other researchers (Rotmans et al. 2001; Loorbach 2010). The transition management and governance framework addresses complex, unstructured, persistent problems of a specific type that "cannot be solved with simple, short-term solutions" (Loorbach 2010, p. 164). The framework includes a process model that comprises policy

design and is intended to develop transition strategies toward sustainability (Loorbach 2010). The framework has been applied and evaluated in several "transition experiments," including transition projects on regions, industry, and business, as well as societal sectors (health and energy sector), originally mainly in Belgium and the Netherlands (Loorbach and Rotmans 2010). However, formal impact evaluations are still missing, in part due to the long-term approach of the transition experiments conducted. What types of methods are being adopted and how they are sequentially combined in the transition management and governance research framework are indicated in Table 3.1.[2] The transition management and governance research framework focuses on both the problem and, to an even greater degree, the vision. From these reference points, transition strategies are being developed and tested in transition experiments. The main emphasis is put on the developing, testing, and multiplying of these transition strategies, which are elaborated in several sub-steps. Variations of the transition management and governance framework incorporate, among others, the backcasting approach (Voß et al. 2009), which is, however, a complete framework by itself and therefore discussed separately below.

The third framework is the *backcasting* approach developed beginning in the early 1980s by John Robinson (2003). Others have further developed the backcasting framework or developed alternative backcasting frameworks (e.g., Holmberg 1998; Quist and Vergragt 2006). The backcasting framework has been developed to address "complex societal problems such as sustainability challenges" (Robinson 2003, p. 842). The framework leads from "articulating the nature of the desired endpoint conditions" to "analysing how those may be achieved" (Robinson 2003, p. 848 f.). In more recent projects, the framework has been used for fostering social learning and building collective capacity for sustainability (Robinson 2003). The backcasting framework has been applied in various research projects on energy, regional development, and climate change (e.g., Robinson 2003; Quist and Vergragt 2006). Reflexive impact studies provide initial evidence of the impacts of backcasting studies (Robinson et al. 2011; Talwar et al. 2011). What types of methods are being adopted and how they are sequentially combined in the backcasting research framework are indicated in Table 3.1. The rationale behind the backcasting research framework is best understood through the intention of building an alternative to the forecasting approaches predominant in energy and resource studies in the 1970s and 1980s. In response to the challenges of prediction and guidance for action, the backcasting framework employs an explicitly *normative* scenario approach (versus predictive or exploratory future studies) combined with methods that construct *pathways* of "how desirable futures can be attained" (Robinson 2003, p. 842). The approach puts strong emphasis on the construction of desirable and sustainable

[2] While the methods are structured sequentially in this process model, Loorbach (2010) emphasizes the flexible character of the model: "In reality, there is no fixed sequence of the steps in transition management. The cycle only visualizes the need to connect activities and presents some possible logical connections but does not suggest a sequential order of activities" (p. 172). This position supports the general concept employed in this chapter that there is no single right way of creating solution options for sustainability problems (there are multiple). Yet, most of the empirical transition research projects follow the outlined sequence.

future states. The title of the framework indicates the intention of "working backwards from a particular desired future end-point or set of goals to the present, in order to determine […] the policy measures that would be required to reach that point" (ibid.). With its more recent turn toward capacity building and social learning as main objectives, the framework and its applications tend to put even more emphasis on the creation and construction of sustainable future visions than on the actual backcasting part. The backcasting framework is, for instance, similar to the sequence of sustainability science components suggested by Kajikawa (2008).

The fourth research framework is the *integrated planning research* approach developed beginning in the 1990s by Roland Scholz and other researchers (Scholz and Tietje 2002; Scholz et al. 2006; Wiek and Walter 2009). The integrated planning research framework addresses a new kind of complex systemic and ill-defined problem that requires a new type of problem solving (Scholz et al. 2006). The framework intends to contribute to societal problem-solving efforts through methodologically sound research that yields strategies toward sustainability (Wiek and Walter 2009). It has been applied in numerous empirical studies addressing the sustainability challenges of a railroad company, a regional economy, a national nuclear waste disposal program, and so forth (Scholz et al. 2006; Krütli et al. 2010). Evaluative studies provide first evidence of the impacts of some integrated planning research projects (Walter et al. 2007). What types of methods are being adopted and how they are sequentially combined in the integrated planning research framework are indicated in Table 3.1. The rationale behind the integrated planning research framework is the recognition of ill-defined problems combined with the conviction that the current status bears the potential for its transformation in itself. Ill-defined complex problems require extra effort to understand the systems in which they are positioned. A thorough understanding of the current state, its inertia, and future path dependencies (foresight) allows for revealing the current and near-future opportunities to change this path. The integrated planning research framework shares basic assumptions with similar planning research and integrated assessment frameworks (e.g., Ravetz 2000).

Based on the review presented in this section, we can summarize that there are at least four distinct ways, or *frameworks*, to create solution options for sustainability problems (with several sub-variations). These frameworks are differentiated through the specific sequence of methods. While all four frameworks comply with the requirement to arrange and combine methods from all essential families of methods, they put relative emphasis on the different steps/methods within each framework. For simplification purposes, one might summarize that the complex problem-handling framework puts emphasis on the problem analysis (what is the structure of the problem?), the transition management and governance framework on strategy building (what is a promising transition/intervention strategy?), the backcasting framework on visioning (what is a sustainability vision?), and the integrated planning research framework on foresight and sustainability assessment (how might the problem develop in the future and how sustainable are different future states?). All these questions are legitimate questions, and there is no universally "right" way to develop solution options for sustainability problems. Selecting the most

appropriate framework depends on several factors, including the specific context of the problem, the capacity of the research team, and so forth.

A recently developed framework, called TRANSFORM, synthesizes key features of the aforementioned frameworks and integrates foresight, backcasting, and intervention research (Fig. 3.1) (Wiek et al. 2011, 2012, 2013; Lang and Wiek 2012; Wiek 2014). The TRANSFORM framework, similar to the other ones, has been designed for developing solution options for sustainability problems and eventually to *transform* the status quo toward sustainability. It entails two corresponding, yet reverse and complementary, research streams: the first is *foresight*, in which researchers analyze and assess past and current states of the problem, as well as project the problem into the future to depict the diversity of plausible future states (I and IIa); the second stream is *backcasting*, in which researchers construct and assess sustainable future visions, as well as trace these visions back to the current state of the problem (pathways) (IIb and I). As indicated in the figure, scenarios and visions inform and complement one another. Finally, researchers design and test *transition and intervention strategies* (III) that contribute to mitigating the current state of the problem, achieving the sustainable visions, and actively avoiding undesirable scenarios. In order to use a broad evidence base, build capacity, and develop shared ownership for the intervention strategies, this framework calls for a close collaboration of researchers from different disciplines and stakeholders in government, businesses, and civil society. The TRANSFORM framework has been applied to projects on urban sustainability, including land-use planning, mitigating urban sprawl effects, water governance, mitigating childhood obesity, and transit-oriented development (Wiek et al. 2012; Kay 2012; Xiong et al. 2012; Bernstein et al. in press; Wiek et al. in press).

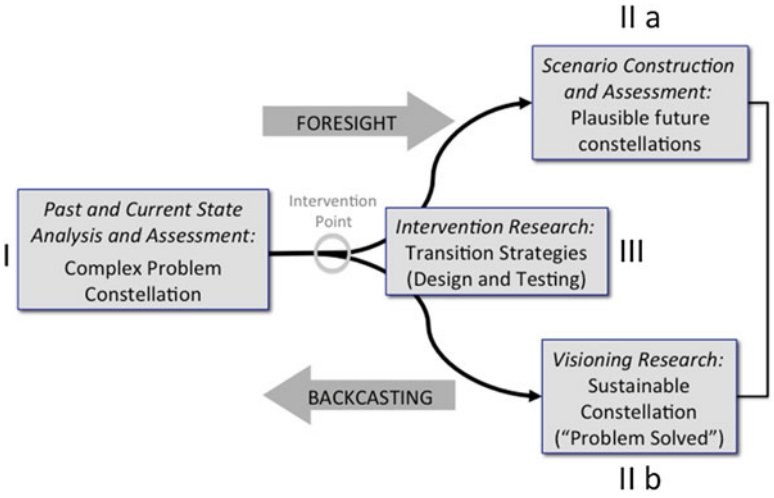

Fig. 3.1 Basic structure of TRANSFORM, a methodological framework for transformational sustainability research integrating foresight, backcasting, and intervention research (Adapted from Wiek et al. (2011))

- **Tasks**:
  1. *Given the characteristics of the methodological frameworks introduced, elaborate on potential strengths and weaknesses with regard to fostering sustainability transitions. For specific sustainability problems, argue why one of the frameworks might fit better than the other ones.*
  2. *Imagine a specific sustainability challenge. Describe this challenge in a few sentences, and develop a rough outline for a transformational sustainability research project, using the TRANSFORM framework that integrates foresight, backcasting, and intervention research (Fig. 3.1). Outline for each step (module): (1) what is being done, (2) who is involved, and (3) what are the expected outcomes?*

3 Outlook

Transformational sustainability research develops evidence-supported solution options for sustainability problems. It shares with descriptive-analytical research the intention to provide credible knowledge, i.e., sufficient evidence for the effectiveness of the interventions. Yet, it differs with respect to the ultimate objective of fostering transformation. There is not one but several methodological frameworks that can guide students, researchers, and professionals in their transformational sustainability research pursuits. All these frameworks have their particular focal points, be it the problem, the projected trajectories of the problem, the goals (or visions), or the intervention strategies themselves. More recently, efforts have been undertaken to synthesize the key features of those frameworks in order to avoid blind spots and fully utilize their strengths.

While progress is being made, there are several challenges ahead. Minor ones relate to a more careful comparison of the different frameworks in order to create a structured pool of frameworks. Such a pool would allow for choosing the most suitable framework for a given project and adopting it to the specific objectives and needs. More challenging is to advance the provision of evidence. While each framework provides a good initial structure, the ultimate objective is to generate evidence-supported solution options. The majority of research projects currently undertaken can still benefit from enhancing their efforts to demonstrate empirically that the designed solution options actually work in practice, as well as to learn from what has not worked. This anticipates the third and major challenge, which pertains to the issue of urgency. The reviewed frameworks offer robust guidelines for transformational sustainability research. Yet, willingness and capacity of academic, governmental, private, and nonprofit organizations to embrace these frameworks fully and use them for their knowledge-generating operations is still fairly low. The mismatch between the call for transformational results and the inertia of business-as-usual operations prevails. Much more needs to be done individually and collectively in transforming societies, governments, and companies around the world toward sustainable trajectories.

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