Requirements for Multi-Method Approaches to Sustainability Assessment – A Theoretical and Empirical Study

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The European Conference on Sustainability, Energy & the Environment 2018
Official Conference Proceedings

Abstract
One key element of furthering sustainable development in politics, society, economy and technology is analyzing and assessing the sustainability of products, processes, strategies and organizations. For this, there are numerous approaches to sustainability assessment. Due to the multi-perspective, multi-dimensional and complex nature of sustainability issues, an increasing number of approaches aims at integrated, holistic assessments, e.g. regarding multiple sustainability dimensions, life cycle phases, input types or stakeholder-perspectives. In this context, a growing focus lies on multi-method or combined approaches. Due to this variety and rapid developments, as of yet, there is no systematic overview of requirements for multi-method approaches to sustainability assessment. This impedes structured comparisons and well-founded selection of suitable approaches for respective assessment situations, as suitability and fulfillment level of requirements are neither comprehensible nor verifiable. To fill this gap, the objective of the proposed work is to contribute to developing a set of requirements for multi-method sustainability assessment approaches. The development is based on a theoretical and an empirical pillar: first, existing approaches and requirements-sets are analyzed based on relevant literature to deduce an initial requirements-selection. Second, a first round of semi-structured, qualitative expert interviews is conducted and evaluated to begin gathering and systemizing insights from sustainability assessment experts from science and practice. Both, the theoretical and empirical indications are then consolidated to develop a preliminary requirements-set. The results contribute to developing a holistic systematization and comparison framework and, thus, facilitate well-founded approach selection. This fosters sustainable development by providing valid and credible assessment results.

Keywords: Sustainability Assessment; Methodological Requirements; Expert Interviews; Multi-Method Approaches

Introduction

In the light of today's major societal issues, such as climate change, scarce resources, environmental pollution, social inequalities and increasing environmental awareness sustainable development and sustainability are widely acknowledged as international, political and societal goals. This is underlined by the seventeen Sustainable Development Goals (SDGs), published and implemented by the United Nations (UN) in 2016, which now represent the core of numerous national sustainability strategies (United Nations, 2016). Also, businesses and other organizations increasingly include the SDGs into their strategies. Sustainable development and sustainability seem to have surpassed the stage of being idealists' goals. However, there is a broad consensus, that our society is only at the beginning of tackling the great issues mentioned above. Thus, claims for (more) sustainable practices and principles can be observed in diverse fields, such as politics, society, economy and technology (Azevedo, Godina, & Matias, 2017; Ghadimi, Yusof, Saman, & Asadi, 2013; Ness, Urbel-Piirsalu, Anderberg, & Olsson, 2007; Singh, Murty, Gupta, & Dikshit, 2009).

To foster sustainable development, which is considered as the pathway to sustainability (Reid, 2013), stakeholders, and especially decision makers, need contextual information on the progress towards sustainability – i.e. the status quo, target values as well as short- and long-term actions to promote sustainable development (Bebbington, Brown, & Frame, 2007). For this, there are numerous approaches to measure, analyze and assess sustainability (Bebbington et al., 2007; Ghadimi et al., 2013; Ness et al., 2007). Examples for approaches, used in the context of sustainability assessment are Life Cycle Assessments (LCA), Multi-Criteria-Decision-Analysis (MCDA) approaches or System Dynamics Modelling (SDM), to name but a few (Bitter, Janssen, Vossen, & Hees, 2018). Within this multitude of approaches, a growing focus lies on multi-method approaches, which aim at accounting for the complexity of sustainability issues – i.e. multi-dimensionality, life cycle and supply chain perspectives, multi-stakeholder contexts, subjectivity etc. (Bond, Morrison-Saunders, & Pope, 2012; Hacking & Guthrie, 2008; Hák, Moldan, & Dahl, 2012; Waas et al., 2014).

An increasing number of publications on the subject of sustainability assessments cover the state of the art of assessment approaches including detailed descriptions of approaches, qualitative comparisons based on potentials and limits of approaches as well as guidelines for selection and comparison (cf. section References). However, there is a lack of publications on systematization and comparison frameworks and comprehensive criteria-sets for approach characterization (Bond et al., 2012; Ghadimi et al., 2013). Such frameworks and respective criteria-sets, based on a solid theoretical foundation, could, however, aid a structured selection and comparison of suitable approaches for different assessment contexts. That way, potential assessment errors, inconclusive results or vulnerability towards criticism and doubts regarding the assessments' credibility, are reduced (Gasparatos & Scolobig, 2012). Such effects can be results of choosing unsuitable assessment approaches and have the potential to decelerate sustainable development. To close the identified gap, the authors' overarching research goal is to develop a comprehensive systematization and comparison framework for multi-method sustainability assessment approaches. In the in the early stages of framework development, two central questions arise, that need to be answered to move forward:

1) How can multi-method sustainability assessment approaches be described, characterised and thus, systemized and compared?
2) How should current, potential and future multi-method sustainability assessment approaches be designed from users' perspectives?

A comprehensive set of systematization and comparison criteria, as proposed by Bitter et al. (2018) provides an answer to the first question. It can be used to describe and characterize assessment approaches and thus, provide potential users of the developed framework with necessary background information and a structured overview of approaches' characteristics. However, the current version of the criteria-set merely allows for a qualitative description of assessment approaches. To facilitate a more structured systematization and reliable comparisons, comprehensible scales for the criteria are needed (Bitter et al., 2018). Building on the first one, the second question aims at finding target values for the criteria as well as insights regarding relevance and importance of each criterion. These two aspects contribute to scale development and building a basis for more structured approach selection processes for users of the framework. Target values as well as weights of criteria can be deduced from requirements, which express desires and/or needs of users of sustainability assessment approaches. In other words: requirements represent *how assessment approaches should be designed from users' perspectives*.

Focusing on the second research question, the goal of this paper is to contribute to developing a requirements-set for multi-method sustainability assessment approaches. To reach this goal, theoretical insights from an analysis of literature on sustainability assessment as well as requirements for approaches in this field, are combined with first empirical indications from interviews with experts in the field of sustainability assessment (cf. Figure 1).

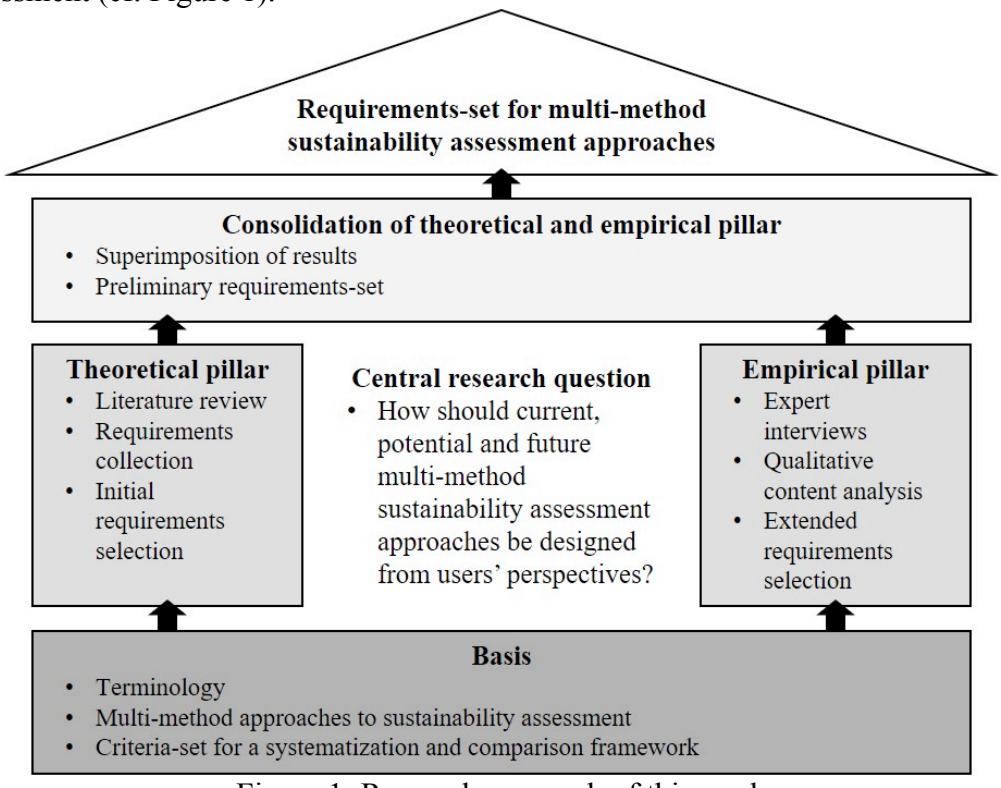

Figure 1: Research approach of this work

The remaining sections of this work are structured as follows. In the next section, the terminology used in this study is defined and described. Subsequently, an overview of multi-method approaches to sustainability assessment is given and the criteria-set, proposed by Bitter et al. (2018), is presented to describe, characterise, systemize and compare approaches. Following, the methodology of literature analysis (i.e. theoretical pillar) and expert interviews (i.e. empirical pillar) is described. Then, insights from literature analysis, including a first requirements selection are presented before results from first expert interviews are presented and linked to the theoretical findings. Finally, conclusions are drawn and an outlook is given in the last section.

Terminology – Sustainability, Sustainability Assessment, Methodological Perspectives

Despite an increasing focus on *sustainable development*, *sustainability* and respective principles, as of yet, there is no undisputed definition of the terms. However, building on the UN's definition – *"sustainable development […] meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland et al., 1987) – a *"commonly accepted notion of sustainability describes a holistic concept, that tries to reconcile human activities with the carrying capacity and exhaustibility of the natural environment and human needs – today and in the future"* (Bitter et al., 2018). The widely acknowledged sustainability dimensions *ecology*, *economy* and *social issues* reflect this notion, which is also adopted in the present work (Gibson, 2006; Kleine & von Hauff, 2009). Similarly, to date, there is no agreement on one single definition of the term *sustainability assessment* (Bond et al., 2012). Also, there are parallel terms, such as *sustainability appraisal*, *integrated assessment* or *sustainability impact assessment*, which all lead in the same direction and are – for the purpose of this study – viewed as synonyms (Pope, Bond, Hugé, & Morrison-Saunders, 2017). What all of these terms have in common is that they see the assessment as *"[…] a process that leads decision making towards sustainability"* (Bond & Morrison-Saunders, 2011; Bond et al., 2012; Hacking & Guthrie, 2008). This generic definition, however, leaves a lot of room for interpretation, which leads to a broad variety of approaches (Bond et al., 2012).

In the context of sustainability assessment there is a wide range of terms being used by different authors (Sala, Farioli, & Zamagni, 2013). This does not only apply for sustainability assessment itself, but also for different levels of methodological perspectives on the assessment and its elements. Terms being used in this context are, for example, *framework*, *concept*, *approach*, *methodology*, *method*, *model*, *tool*, *index*, *indicator* and more (Bitter et al., 2018; Sala et al., 2013). While it is not the aim of this work to define all these terms conclusively, for a better understanding, the ones used in this work are described and put into context in the following Figure 2.

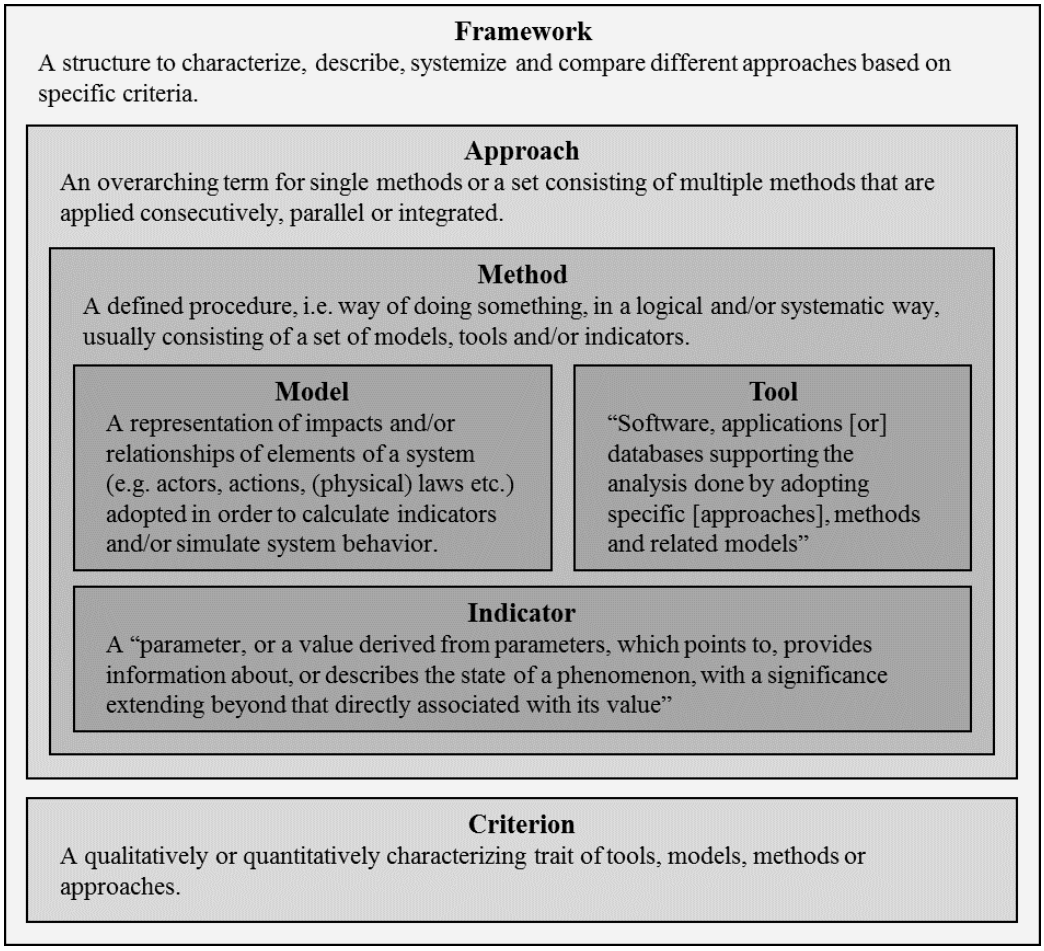

Figure 2: Terminology adopted in this work and hierarchical context (derived from: OECD, 2003; Sala et al., 2013)

Multi-Method Approaches to Sustainability Assessment

Sustainability assessment approaches are generally applied in various fields, such as the assessment of products, processes, businesses and organizations or politics. Their main objective is to measure, analyze and assess the (progress towards) sustainability of the respective assessment object and thus provide decision making support (Azevedo et al., 2017; Ghadimi et al., 2013; Ness et al., 2007; Singh et al., 2009). In recent years, multi-method or combined approaches have increasingly been put into focus in the context of sustainability assessment. This relates to two main factors. First, sustainability and sustainable development are complex constructs and an increasing number of assessment approaches is tailored to account for this fact (Sala, Ciuffo, & Nijkamp, 2015). In this context, complexity refers to multidimensionality – i.e. ecology, economy, social issues – a life cycle or supply chain perspective, a multitude of stakeholders and actors affected by and/or involved in the respective issue, dynamic properties and an interrelatedness of factors, to name but a few. Single approaches are seldomly equipped to account for the full complexity of sustainability issues, thus multiple methods are combined (Sala et al., 2015). Second, sustainability assessments can generally encompass different assessment process stages, such as *stakeholder and indicator selection*, *data collection and pre-processing*, *assessment logic*, *representation of results*, and *derivation of measures*. Approaches consider either single stages, multiple stages or fully integrate all stages (Bitter et al., 2018; Hacking & Guthrie, 2008). Different assessment methods are suitable for different

process stages, thus, commonly, to include multiple stages or reach an integrated assessment, multiple methods are combined (Liu, 2014; Wang, Jing, Zhang, & Zhao, 2009). It is neither feasible nor expedient to present and discuss all existing approaches to sustainability assessment within this work. Examples are *Life Cycle Sustainability Assessment* (LCSA), a combination of *LCSA and SDM* or the *Fuzzy Logic Approach to Sustainability Assessment Based on the Integrative Sustainability Triangle* (Fuzzy-IST). An extensive review of multi-method approaches to sustainability can be found in Bitter et al. (2018). Further descriptions of mentioned and unmentioned approaches used in the context of sustainability assessment can be found in the relevant literature (cf. section References). To facilitate description, characterization and thus, systematization and comparison of the enormous variety of multi-method sustainability assessment approaches, the overarching research goal is the development of a systematization and comparison framework based on a comprehensive criteria-set. This is presented in the following section.

Criteria-Set for a Systematization and Comparison Framework

Based on a review of multi-method approaches for sustainability assessment as well as existing frameworks and categorizations Bitter et al. (2018) propose a set of 20 criteria to characterize sustainability assessment approaches. Table 1 contains the criteria and short descriptions. An exemplary characterization of the Fuzzy-IST using the criteria-set can be found in Bitter et al. (2018).

Criterion	Description
Category of approach	E.g. LC, MCDA or other approaches as well as further subcategories (e.g. outranking, distance-to-target etc.)
Focused sustainability dimension	Ecology, economy and social issues or approaches, considering intersections of two or all three dimensions
Focused LC stages and/or parts of the supply chain	Which parts of the LC and/or supply chain are included, up to holistic approaches, integrating the entire LC/supply chain
Included assessment-process elements	The focus on different process stages
Type of input data	E.g. quantitative or qualitative data, numerical or linguistic inputs
Scope of application or generalization level	Targeted range of applications for different objects of investigation
Level of integration	Assessment of different aspects (e.g. sustainability dimensions/LC phases) integrated or side-by-side
Standardization and transparency	Level of comprehensibility and repeatability of assessment processes and results
Data sources	Primary or secondary data, expert knowledge, simulations, analogies or others
Weighting and/or normalization of indicators or criteria	If and which type of weighting and/or normalization is incorporated
Output type	absolute or relative measure(s), single or multiple numerical output(s), graphical representation
Dynamism	Assessment based on a static state ("*snapshot*") or on a dynamic model, that considers interdependencies
Temporal characteristics	Retrospective/descriptive or prospective/predictive evaluation

Table 1: Systematization and comparison criteria, as proposed by Bitter et al. (2018)

Criterion	Description
Treatment of uncertainties	If uncertainties are ignored, deliberately incorporated, minimized etc.
Ease of use or applicability	The cost (time, money, effort) for conducting the assessment and accessibility of assessment procedures and principles
Participation and democracy	How stakeholders and/or experts are involved in the assessment
Accuracy or level of detail	Precision and reliability of the assessment from rough estimate or general tendency to exact output
Substitutability of indicators/ dimensions or handling of trade-offs	Degree to which indicators or sustainability dimensions balance out negative/positive effects of other indicators/dimensions
User(s) and/or target group(s)	E.g. decision makers, analysts, private individuals
Number of combined methods	-

Table 1 (cont.): Systematization and comparison criteria, as proposed by Bitter et al. (2018)

The criteria-set, as a first step towards framework development, enables systematization and comparison of existing and potential, new method combinations for sustainability assessment. That way, a structured selection process is facilitated, that goes beyond generic rules or guidelines. The current version of the criteria-set, however, has two major shortcomings. First, it currently merely allows for a

qualitative description of assessment approaches (Bitter et al., 2018). Consistent scales for each criterion would facilitate a more structured and somewhat standardized classification of assessment approaches within the framework and thus, comparison between approaches. Such scales could be, for example, binary, e.g. *yes/no*, based on linguistic sets, e.g. *bad – medium – good*, or a numerical interval, e.g. *[0,1]* as degree of fulfillment. To develop consistent scales target values for criteria are needed, that can be used as lower and upper thresholds. Second, the set of 20 criteria might be comprehensive, as it represents various characteristics of assessment approaches, but the current version does not provide any insights about possibly differing relevance and/or weights of different criteria. In this context, it needs to be validated, if all of the 20 criteria are equally relevant or necessary for a sufficient systematization and comparison of assessment approaches. To tackle these shortcomings and drive the framework development forward, in this work, requirements for multi-method sustainability assessment approaches are collected. The methodology applied for building a requirements-set is further elaborated in the following section.

Methodology – Theoretical and Empirical Pillars

To include theoretical insights from the magnitude of existing literature on sustainability assessment approaches as well as practitioners' expertise and standpoints, the present work is based on a two-pillar approach: theoretical and empirical. To build the first one, three sub-steps are followed:

1) Literature review of scientific sources related to multi-method sustainability assessment approaches and existing requirements-sets
2) Collection of requirements for multi-method sustainability assessment approaches, mentioned and/or described in the literature reviewed
3) Clustering of synonymous and/or related requirements in form of an initial requirements selection

For the second pillar, semi-structured, guideline-based expert interviews (Bogner, Littig, & Menz, 2009) are conducted and evaluated using qualitative content analysis, based on Mayring (2014). A semi-structured approach using an interview guideline allows the interviewer to adapt to the course of the conversation and, if necessary, to deviate from the interventions included in the guideline. Thus, experts' knowledge and opinions can be freely explored while at the same time, the guideline provides an easy to follow structure for the interviewer (Bogner et al., 2009). The interview guideline consists of ten open interventions, clustered in five phases (cf. Table 2). It is subject to continuous adaption based on insights from the conducted interviews. The focused topics, however, remain constant through all interviews. The target group of the interviews are experts in the field of sustainability assessment. This includes interview partners from the scientific world, economic enterprises, politics and administration as well as non-governmental organizations.

Phase / Topic	No.	Intervention
Initial impulse	Q1	Please describe to me your understanding of the term "sustainability assessment".
Sustainability assessment practices	Q2	There are numerous approaches or methods for sustainability assessment. Which one(s) do you use or have used before?
	Q3	In which contexts do you use or have you used these methods?
	Q4	What goal(s) are or were you aiming at by applying these methods?
	Q4a	*Which other approaches to sustainability assessment do you know? (optional)*
Requirements for sustainability assessment approaches	Q5	When selecting an approach for a specific assessment context, what are your selection criteria?
	Q6	Considering these criteria, what are general requirements for approaches to sustainability assessment?
	Q7	When thinking about the assessment contexts you are familiar with, as discussed before, what are specific requirements for sustainability assessment approaches regarding these contexts?
Fairness	Q8	I have one last question for you. One requirement for approaches to sustainability assessment might be to provide a "fair" assessment. In your opinion: what would be an appropriate definition or description of "fair" in this context?
Additional aspects	*Q9*	*Do you have any additional comments or aspects, that you would like to talk about?*

Table 2: Interview guideline (phases / topics and interventions)

The expert interviews are audio-recorded and evaluated based on Mayring (2014). The goal of the evaluation is to reconstruct the interviewees' ideas, expertise and opinions from interview data, based on a theoretical framework, guided by rules, systematic and thus, comprehensible for third parties. A qualitative content analysis consists of five steps:

(1) transcription of audio-recording, (2) redaction of statements based on initial questions, (3) organizing statements according to topics, (4) explication, i.e. interpretation and explanation of interviewees' ideas, expertise and opinions and (5) structuring of contents and concepts (Mayring, 2014). Based on this evaluation, in the context of this work, requirements for sustainability assessment approaches are collected. Similar to the first pillar, the collected requirements from different interviewees are clustered according to synonymous and/or related aspects. At the time of publication, N = 4 interviews have been conducted and evaluated. Further interviews are scheduled and thus, the results of the empirical part of this work should be understood as preliminary.

As a third step, the results of both, the theoretical and the empirical pillar are consolidated. For this, the collected requirements-sets are compared and synonymous and/or related aspects are clustered. Thus, by superimposing both sets, a first requirements-set is developed. In the following sections, insights from both pillars and from a preliminary consolidation of the resulting requirements-collections are presented.

Theoretical Insights – Initial Requirements Selection

The literature reviewed can be divided into two main categories (C1 and C2). On the one hand, sources containing *implicit* insights about requirements for sustainability assessment approaches (C1). In many cases, these works are concerned with various approaches, including those regarding the state-of-the-art or specific groups of approaches, e.g. LC approaches, MCDA approaches, approaches for assessments on product or company level etc. On the other hand, sources providing *explicit* statements or collections of requirements – i.e. descriptions how approaches to sustainability assessment should be designed (C2). Sources, that explicitly cover requirements for sustainability assessment approaches, on the one hand, confirm the initial findings from the first category. On the other hand, new aspects can be added to the overview. In some works, terms like *criteria* (Baumgartner, 2004; Thabrew, Wiek, & Ries, 2009) or *principles* (Pintér, Hardi, Martinuzzi, & Hall, 2012; Wang et al., 2009) are used instead of *requirements* (Bitter et al., 2016; Liu, 2014; Sala et al., 2015, 2013). However, all of these terms refer to statements or claims, how sustainability assessment approaches should be designed and are thus, understood as synonyms for the purpose of this work.

In the following Table 3, the initial requirements-selection from literature analysis, consisting of 25 requirements (R1–R25), is summarized. The table contains a short description of each requirement and sources of both categories. The requirements are sorted according to the number of sources.

No.	Requirement	Sources
R1	Include a **holistic perspective** of the sustainability dimensions	[8]–[10], [12], [14]–[20]
R2	Include **strategic perspective** to **contribute** positively to sustainable development	[5], [9], [14]–[20]
R3	**Systemically** reflect relevant characteristics and impacts	[1], [11], [16], [18], [20], [21]
R4	Foster **comparability** and **objectivity** of inputs, processes and results	[3], [11], [13], [16], [18], [21]
R5	Allow for **stakeholder** participation and **transdisciplinary** processes	[6], [16], [18]–[20]
R6	Provide a **life cycle perspective**	[7], [8], [10], [12], [20]
R7	Focus on **integrated assessments**	[8], [12], [14], [17], [19]
R8	Represent the individual and overall **performance** of indicators	[6], [15], [16], [18], [19]
R9	Assure **consistency** of inputs, assumptions, system boundaries, results	[1], [4], [7], [21]
R10	Clear, understandable **communication** and/or **visualization** of results	[1], [12], [16], [20]
R11	Include only **measurable**, boundary-oriented indicators	[15], [16], [19], [21]

Table 3: Initial requirements-selection and sources

No.	Requirement	Sources
R12	Assure **reliability** and **validity** of inputs, processes and results	[11], [13], [15]
R13	Process **uncertainty**, **subjectivity** and **incomplete** data-sets	[12], [18], [19]
R14	Focus on **transparency** of inputs, assumptions, overall approach, results	[16], [19], [20]
R15	Processing of **quantitative AND qualitative** data	[2], [12]
R16	Recognize and **avoid trade-offs**	[7], [10]
R17	Provide a **practicable**, i.e. usable, feasible and efficient approach	[11], [12]
R18	Assure an **adequate** temporal and/or geographical **scope** of assessment	[15], [16]
R19	Facilitate a **continuous**, **flexible** assessment process	[16], [20]
R20	Provide **decision making support**	[1], [15]
R21	Foster **scalability** and **transferability** of results	[18], [19]
R22	Deal with **cross-sectoral** issues	[20]
R23	Allow for the assessment of different scenarios	[20]
R24	Avoid **independencies** and/or account for **interdependencies**	[21]
R25	Promote (social) **learning** and feedback	[18]

Legend:
C1 sources: [1] = (Abu-Taha, 2011), [2] = (Andriantiatsaholiniaina, Kouikoglou, & Phillis, 2004), [3] = (Cherchye, Knox Lovell, Moesen, & Van Puyenbroeck, 2007), [4] = (Gamboa & Munda, 2007), [5] = (Gibson, 2006), [6] = (Hermans, Erickson, Noordewier, Sheldon, & Kline, 2007), [7] = (Kloepffer, 2008), [8] = (Møller, Slentø, & Frederiksen, 2014), [9] = (Pope et al., 2017), [10] = (Valdivia et al., 2011);

C2 sources: [11] = (Baumgartner, 2004), [12] = (Bitter et al., 2016), [13] = (Chatterji & Levine, 2006), [14] = (Hacking & Guthrie, 2008), [15] = (Liu, 2014), [16] = (Pintér et al., 2012), [17] = (Pope, Annandale, & Morrison-Saunders, 2004), [18] = (Sala et al., 2013), [19] = (Sala et al., 2015), [20] = (Thabrew et al., 2009), [21] = (Wang et al., 2009);

Table 3 (cont.): Initial requirements-selection and sources

Preliminary Expert Interview Results

At the time of publication N = 4 expert interviews have been conducted. Three of the experts interviewed are from the scientific world (E1–E3) and one is from an economic enterprise (E4). In the following, the interviewees' responses are summarized and clustered according to the topics and questions, as presented in Table 2. Similarities and differences between the expert interviews are highlighted.

- **Q1 – Understanding of "sustainability assessment"**: The scientists' understanding of sustainability assessment incorporate the three sustainability dimensions ecology, economy and social issues, with a greater focus on ecology, representing the concept of *strong sustainability* (Morrison-Saunders, Pope, & Bond, 2015). For them, these dimensions are represented by indicators and target values to measure the status quo or progress towards sustainability. The expert from industry (E4), however, makes no differentiation between sustainability assessment and other business-related assessments, as sustainability is seen as integral part of the enterprise's strategy.

- **Q2 – Applied approaches to sustainability assessment**: The experts use various approaches to sustainability assessment. Some of them are mentioned multiple times, some just once. E1–E3 use *LC-based approaches* with comprehensive or reduced indicator sets and varying foci (e.g. carbon footprint, climate aspects, resources). Their main focus lies on the concept of *material input per unit of service* (Liedtke et al., 2014). E2 and E3 also use *Hot-Spot Analysis*, a qualitative approach based on literature analysis and expert interviews (Liedtke, Baedeker, Kolberg, & Lettenmeier, 2010). Other approaches that are mentioned by E2 are *resource efficiency potential analysis* (REPA) and *risk analysis*, which are both mainly quantitative approaches. Also, *network* and *media analyses* are used by E3 to qualitatively identify relevant stakeholders for sustainability issues as well as analyzing sustainability-related discourses or popular perceptions. Furthermore, E3 names *nutritional footprinting* as an approach to combine quantitative, resource-focused sustainability assessments with the dimension of health (Lukas, Rohn, Lettenmeier, Liedtke, & Wiesen, 2016). E4 stresses, that there is no differentiation between sustainability assessments and other assessments in the company. An approach, that has been used in the past is *stakeholder surveys*, in the sense of *materiality analyses*, to investigate the relevance of different topics and estimate the company's performance regarding relevant topics. Another approach is to qualitatively and quantitatively *estimate* possible ecological and social *impacts* of the company's actions as a decision basis for the members of the board of directors. This approach was phased out and replaced by a streamlined document-based tool accompanied by coordination processes prior to strategic decisions. E4 points out, that the approaches being used are not standardized, but rather tailored to the company's needs and structures.
- **Q3 – Context of sustainability assessments**: The contexts, in which the interviewees apply the abovementioned approaches to sustainability assessment, are broad. E1 argues to look at "everything" and names examples, such as *products*, *materials*, *supply chains* and *national economies*. E2 focusses on *comparing* assessments of *products* and production *processes* but also mentions assessments of *households* and individual *lifestyles* as well as bio-energy, biomass, agriculture and related *impacts*. E3 is mainly concerned with *products*, *services*, *processes* and *households* but also deals with *systemic* assessments, for example related to *supply chains* or *city quarters*. This expert also differentiates assessment contexts into research projects and sustainability consulting for third parties, such as companies or government. E4's single focus lies on assessments prior to strategic decisions, which can be regarding, for example, investments, products, business relationships or communication.
- **Q4 – Goals of sustainability assessments**: Assessment goals that are mentioned multiple times are to *optimize* products, processes or entire companies (E1–E4), to *prepare decisions* on different levels, e.g. households, companies or national economies (E1, E3, E4) and to *compare* different alternatives, e.g. products, strategies or lifestyles (E1–E3). E1 also mentions, in the past, one goal was to *develop a database* resource analyses but this goal was abandoned, as extensive databases already exist. E2 names the *reduction of impacts*, e.g. of resource consumption, as an overarching goal. E3's prioritized goal is to *foster a sustainable transformation* of society and contribute to providing insights on *"real" sustainability* values of practices,

products and services. For E4, a main goal is to *embed sustainability concepts* (e.g. the Triple-Bottom-Line) into the company's "DNA".

- **Q5 – Selection criteria for sustainability assessment approaches**: All experts argue, that there are *no specified, objective selection criteria* in their assessment practice. On the one hand, this relates to a specific set of approaches or methods that are commonly applied in the experts' organizations (see above). On the other hand, the experts point out that method selection always depends on the assessment goal and expected and/or desired results. E1, for instance, mentions "authenticity" as a reason why always the same (resource-focused) approaches are chosen, which are then tailored to the specific assessment context. For E2, it is clear to first define the assessment goal und respective questions and then to select an appropriate approach. E3 states, that methods are chosen according to clients' wishes or requirements and/or according to individual expertise or capacities. Many clients, however, prefer quantitative assessments, as data often is available and results are easy to communicate. E3 also remarks, that commonly it is not questioned whether a method or an approach is suitable and/or sufficient and, for example, should be combined with another method or approach. For E4, there is no selection process at all, as assessment approaches are always pre-defined.
- **Q6/7 – General and specific requirements for sustainability assessment approaches**: The experts do not differentiate between general and specific requirements or the specific requirements they mention overlap with the general ones. In the following Table 4, requirements are listed and attributed to the different experts.

Requirement	**Expert(s)**
Transparency and comprehensibility regarding the assessment process, assumptions, goals and conclusions	E2–E4
Accompany numerical values with context-sensitive verbal explanations / interpretations	E1, E2
Do not overestimate assessment as the "absolute measure"	E1, E2
Provide a long-term perspective	E1, E3
Display a realistic image of the relevant system, e.g. regarding relevant stakeholders, balance of power or influences	E3, E4
Reliability of the assessment and its results and Resilience against external changes and/or changing assumptions	E1
Focus on process-oriented indicators to account for changing conditions	E1
Assure relevance of assessment object	E1
Do not suggest false accuracy / be aware of uncertainties	E1
Chose appropriate scales for assessment object and focused system level	E1
Assure comparability of the assessment and its results	E2
Provide a decision basis	E2

Table 4: Resulting requirements from questions Q6 and Q7

- **Q8 – Fairness**: With regards to a possible requirement of a *fair* assessment, the experts provide their own definitions or descriptions of *fairness* in the

context of sustainability assessment. E1 points out that fairness mainly relates to embedding an assessment into the specific assessment context. The general *conditions*, *system boundaries* and the *position* in the life cycle and/or supply chain need to be considered. Comparisons under different conditions or assumptions, e.g. of different branches, regions, parts of the supply chain, are seen as *unfair*. The expert also remarks that it is crucial to assess the *impact* of single system elements on the entire system, e.g. a product's life cycle or supply chain. E2 names several aspects of a fair assessment. First, for comparisons, the same *assessment basis* needs to be used. Second, with regards to lifestyles and consumption, *resources* need to be *distributed equally*. Third, the overall goals of the assessment need to be in the interest of *public justice* or *equity*. Fourth, a fair assessment should be transparent. The expert also remarks, that assessment results should always be seen as a decision basis, but not as an *absolute truth*. E3, however, connects fairness with targeting the SDGs and their objectives by including *target values* or a target corridor into the assessment. The expert argues, that current standards or recommendations should always be combined and (re-)evaluated with sustainability goals. Finally, E4 suggests that fairness connects to *transparency* regarding communication and goals of the assessment. For business activities, a certain *continuity* and *reliability*, e.g. with regards to the understanding of sustainability, is also relevant for fairness. At last, the expert states that an aspect of fairness is a timely *feedback* from third parties, if sustainability goals are not met, to effectively correct negative impacts.

- **Q9 – Additional remarks**: All experts have additional remarks, that are not directly related to any of the questions above. E1 and E4 point out, that there is a significant *gap* between sustainability assessment practices in the scientific and economic world. The approaches developed by scientists are often too complex and detail-oriented for an implementation in companies. Thus, *streamlined approaches* are needed (E1). E4, as a representative of the economic world, suggests two possible ways to close that gap: either scientists develop (streamlined) approaches which are then used by companies or scientists conduct assessments themselves. According to E4, the results of both ways will most likely be very different. The experts from science, E1–E3, also point out, that assessment results can be easily *influenced* and, thus, *manipulated* by choosing different sustainability assessment approaches. Finally, E4 remarks, that sustainability should not have a *special status*, especially for companies, but be seen as an integral part of the strategy. By avoiding a *parallel world* for sustainability issues, the concept itself might be more successful.

In the third step of this work's research approach, the preliminary results of the expert interviews are linked to the literature analysis. A first consolidation of both pillars is presented in the following section.

Preliminary Consolidation of the Theoretical and Empirical Pillar

The first round of expert interviews provides further insights on requirements for multi-method sustainability assessment approaches. By superimposing their results with the initial requirements selection (cf. Table), several of these requirements are

confirmed by the experts, others are added to the list. The results of the superimposition are presented in the following Table 5.

No.	Requirement	Confirmed / Added
R1	Include a **holistic perspective** of the sustainability dimensions	**Confirmed** (E1–E4; Q1)
R2	Include a **strategic perspective** to **contribute** positively to sustainable development	**Confirmed** (E1–E4; Q4, Q6/7)
R3	**Systemically** reflect relevant characteristics and impacts	**Confirmed** (E1, E3, E4; Q6/7, Q8)
R4	Foster **comparability** and **objectivity** of inputs, processes and results	**Confirmed** (E2; Q6/7)
R6	Provide a **life cycle perspective**	**Confirmed** (E1–E3; Q2)

Table 5: Superimposed requirements-set from the theoretical and empirical pillar

No.	Requirement	Confirmed / Added
R11	Include only **measurable**, boundary-oriented indicators	**Confirmed** (E3; Q8)
R12	Assure **reliability** and **validity** of inputs, processes and results	**Confirmed** (E1, Q6/7)
R13	Process **uncertainty**, **subjectivity** and **incomplete** data-sets	**Confirmed** (E1, Q6/7)
R14	Focus on **transparency** of inputs, assumptions, overall approach and results	**Confirmed** (E2–E4, Q6/7, Q8)
R15	Processing of **quantitative AND qualitative** data	**Confirmed** (E2–E4, Q2)
R17	Provide a **practicable**, i.e. usable, feasible and efficient approach	**Confirmed** (E1, E4; Q9)
R18	Assure an **adequate** temporal and/or geographical **scope** of the assessment	**Confirmed** (E1; Q6/7)
R19	Facilitate a **continuous**, **flexible** assessment process	**Confirmed** (E1; Q6/7)
R20	Provide **decision making support**	**Confirmed** (E1–E4; Q4, Q6/7)
R25	Promote (social) **learning** and feedback	**Confirmed** (E4; Q8)
RA1	Accompany numerical values with context-sensitive verbal **explanations** / **interpretations**	**Added** (E1, E2; Q6/7)
RA2	Do not **overestimate** assessment as the "absolute measure"	**Added** (E1, E2; Q6/7)
RA3	Assure **relevance** of assessment object	**Added** (E1; Q6/7)
RA4	Provide **new insights** regarding the assessment object and create **expert knowledge**	**Added** (E3; Q6/7)
RA5	Promote **ambitious**, but **achievable goals**	**Added** (E4; Q6/7)

Table 5 (cont.): Superimposed requirements-set from the theoretical and empirical pillar

From the previous table, it can be seen that 15 of the 25 initial requirements are confirmed by a small number of experts (N = 4). Another five requirements are added from the interviews. All experts point out that, in their understanding, sustainability is represented by the three dimensions ecology, economy and social issues. Thus, they focus on a *holistic perspective of sustainability* in the context of assessments. This directly relates to R1, which is repeatedly named as a requirement in sustainability assessment literature (cf. Table). This underlines the importance of avoiding one-sided assessments to account for sustainability's complexity. Furthermore, all experts

aim at including a *strategic perspective* into sustainability assessments to contribute positively to sustainable development (R2). Again, being a requirement frequently mentioned in the literature, this stresses the importance of having specific, sustainability-driven goals when conducting an assessment, e.g. improving products or processes. This also links to the unanimously named requirement of providing *decision making support* (R20), which directly reflects sustainability assessments definition as *"[...] a process that leads decision making towards sustainability"* (Bond & Morrison-Saunders, 2011; Bond et al., 2012; Hacking & Guthrie, 2008). Other requirements that are, in each case, stated by three experts, are to *systemically* reflect relevant characteristics and impacts (R3), to provide a *life cycle perspective* (R6), to focus on *transparency* of inputs, assumptions, overall approach and results (R14) and to process *quantitative and qualitative* data (R15), underlining the importance of these requirements.

Conclusion

The results of this work provide a first overview of requirements for multi-method approaches to sustainability assessment, thus, approaching an answer to the question *"How should current, potential and future multi-method sustainability assessment approaches be designed from users' perspectives?"* (cf. section Introduction). The results indicate, that the prevalent requirements are, on the one hand, driven by characteristics of sustainability and, on the other hand, by general desires towards assessment approaches. The first category relates to aspects, such as sustainability as a *holistic* concept, a *strategic* goal, a complex *system* or a *life cycle*-wide issue. The second category includes a perception of assessment approaches fostering *decision support*, being *transparent* or processing multiple types of *inputs*. This points to the conclusion, that multi-method sustainability assessment approaches should be designed to account for the complexities of sustainability while adhering to general standards for assessment approach.

However, due to the small sample size (N = 4), the results of this study cannot be regarded as conclusive. They rather provide valuable indications, as discussed above, on which further research can be based on. Because of this, concrete target values and weights of the criteria and thus, comprehensive scales, could not yet be deduced within this study. However, to finalize the development of a comprehensive requirements-set for multi-method sustainability assessment approaches, more interviews will be conducted. Thus, initial indications from this work shall be validated or contradicted and additional insights about sustainability assessment practices, goals and approach selection processes shall be gained. A next step in framework-development is to relate the systematization and comparison criteria with the requirements-set to deduce target-values, and, thus, scales for the criteria as well as insights regarding relevance and importance of each criterion. That way, the framework being developed, gains in applicability and validity. Thus, method selection and combination for sustainability assessment are structured and facilitated. Finally, this fosters context-adequate, more reliable and valid assessment results and more sustainable decisions.

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