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A framework for strategic sustainable development

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ABSTRACT

The purpose of this paper is to give a comprehensive and cohesive description of the most recent version of the Framework for Strategic Sustainable Development (FSSD), and also to describe and discuss the overall method for developing the FSSD, elaborate on the general rational for and general benefits of a framework of this type, and validate benefits of the FSSD through examples of its application. The purpose is also to point to pertinent future work. In preparation of this paper, we have reviewed previous publications and other documents related to the FSSD and reflected on the 25-year learning process between scientists and practitioners. We conclude that the FSSD has proven to aid organizations in thoroughly understanding and putting themselves in context of the global sustainability challenge, and to move themselves strategically towards sustainability, i.e., to stepwise reduce their negative impacts on ecological and social systems at large while strengthening the own organization through capturing of innovation opportunities, including new business models, exploration of new markets and winning of new market shares, and through reduced risks and operation costs. Specifically, we conclude that the FSSD aids more effective management of system boundaries and trade-offs, makes it possible to model and assess sustainable potentials for various materials and practices before investments are made, and offers the possibility for more effective collaboration across disciplines and sectors, regions, value-chains and stakeholder groups. We also conclude that the FSSD makes it possible to prevent damages, even from yet unknown problems, and not the least, to guide selection, development and combination of supplementary methods, tools, and other forms of support, which makes it possible to increase their utility for strategic sustainable development. Finally, we have shown that the FSSD is useful for structuring transdisciplinary academic education and research. Several examples of ongoing FSSD related research, as well as ideas for future work, are given.

1. Introduction

Humanity faces decreasing ecosystem quality and increasing risk of tipping the biosphere into a state where it would be difficult or impossible to maintain the human civilization (e.g. Steffen et al., 2015). Continued population growth adds to the challenge (United Nations, 2013). In addition, humanity faces social sustainability challenges. There are, e.g., indications of decreasing levels of trust in many societies (e.g. Edelman, 2015). Low levels of trust, besides being a severe social problem in itself, also implies a low potential to cohesively address the ecological challenges. There are also increasing financial impacts related to the unsustainability of the ecological and social systems (e.g. Stern, 2006). All three types of capital – ecological, social and financial – are essential to a sustainable society and for the transition towards such a society.

Transitioning to a sustainable society is obviously a complex endeavor, requiring, e.g., extensive coordinated collaboration across disciplines and sectors. How can humanity hope to succeed with this without having a *unifying and operational definition* of sustainability, and a *systematic approach* to planning and acting for the fulfillment of it? In response to this problem, a consensus process aiming at developing such a definition and approach began in Sweden in the early 1990s (Robèrt, 1992). Several iterations of refinement have taken place (e.g. Robèrt, 1994; Holmberg, 1995; Broman et al., 2000; Robèrt, 2000; Robèrt et al., 2002; Ny et al., 2006; Missimer et al., 2015a, 2015b) and the result is now widely known as the Framework for Strategic Sustainable Development (FSSD).

The purpose of this paper is to give a comprehensive and cohesive description of the most recent version of the FSSD, and also to describe and discuss the overall method for developing the

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FSSD, elaborate on the general rational for and general benefits of a framework of this type, and validate benefits of the FSSD through examples of its application – all, for the first time to this extent and level of detail, in one and the same paper. The purpose is also to point to pertinent future work.

2. Methods

In preparation of this paper, we have reviewed previous publications and other documents related to the FSSD and reflected on the 25-year learning process between scientists and practitioners. The actual development of the FSSD has employed many methods. Examples include: literature studies (on general systems science, earth system science, resource theory, leadership theory, organizational change theory, economics, sociology, and other relevant areas), logical reasoning, hypothesis generation and testing, modeling, action research, case studies, interviews, surveys, etc. The application of these methods is described in previous publications in relation to the respective study. Here, we focus on the overall method, bringing the above together, for developing the FSSD.

In short, the FSSD is elaborated, scrutinized theoretically against empirical data on the sustainability challenge and other existing knowledge and new research results, used and tested among practitioners, elaborated based on the test results, scrutinized theoretically again, etc., in a continuous process. Also the theoretical scrutiny involves iterations. In all, it is a pulsating process driven by a core group of scientists, going to wider circles of scientists to get feedback on scientific rigor and understanding of terms across disciplines, and finally, usually after several iterations between the core group and other scientists, to practitioners to get feedback on usability and to test utility of the FSSD for its intended purpose, as well as to get feedback on understanding of terms across professions and sectors.

More specifically, the core group typically elaborates a supposedly improved version of the FSSD, e.g., a new phrasing of the sustainability definition. This is triggered by and based on feedback from others or experiences and insights of the core group itself, and is supported by literature studies and conceptual modeling (e.g. Brooks, 2007; Kotiadis and Robinson, 2008; Jaccard and Jacoby, 2010). This means that the core group distills key concepts from the literature and tries to understand the relationships of these from a strategic sustainable development perspective. The latter is often done in workshops between the core group scientists, applying semantics and logic reasoning. Specifically regarding the sustainability definition of the FSSD, the theoretical scrutiny also involves a kind of modeling where the scientists study contemporary sustainability issues and test whether they are all covered, and can be clustered under the different sustainability principles that the definition is comprised of. See Section 4.3.

When the core group feels reasonably ready it turns to other scientists with diverse backgrounds (natural scientists, political scientists, economists, etc.). This is also done through workshops, seminars and other forms of scientific dialogue, including publication in peer-review. The main objective is to find out what can be agreed upon as regards the new version, excluding differences in norms, values and preferences that the various groups bring. The different backgrounds are required to make sure that the terms used are understood as intended across disciplines and perceived as generic and basic. A wide range of disciplines is also useful for testing the core group's understanding of the basic scientific knowledge used and the logic reasoning applied. Criticism and sometimes new references and ideas are collected, which lead to more modeling and possibly an adjusted new version.

Testing the generic and unifying qualities intended for the FSSD also involves analyzes of many other frameworks, concepts, methods, tools, etc., to see how they relate to and can support the full scope of strategic sustainable development that the FSSD aims to cover, which inherently also leads to an understanding of how the other forms of support relate to each other. This is a particularly important aspect of the testing since the purpose of the FSSD has never been to replace or exclude other forms of support for sustainable development, but the opposite; to provide a structure that allows for clarification of their respective strengths and aids a coordinated use of them. Examples are given in Section 5.

When the scientific scrutiny has settled, the testing is expanded to practitioners in businesses, municipalities and other organizations. Is the proposed new version really perceived as an improvement with respect to the purpose of the FSSD, including the aspect of how terms are understood by practitioners from different professions and sectors?

So, when reaching out to larger and larger groups it is never about trying to find some kind of common denominator of values and preferences or a general 'wisdom of the crowd' decoupled from a scientific foundation. It is about testing the new versions of the FSSD from the viewpoints of scientific knowledge, semantics, logic reasoning, usability and intended utility. That said, it should perhaps be pointed out already here that the FSSD does not exclude the use of norms, values and preferences. On the contrary. First, that a sustainable society is at all a desirable goal is a normative stance, as further discussed in Section 4.3. Furthermore, when organizations *apply* the FSSD to support society's transition towards sustainability, values and preferences are essential, as further discussed in Section 6.

The described process has also been used when applying the FSSD for consensus work regarding different topics, such as energy, agriculture, etc. The process model is further described and discussed in general by Robèrt (2002) and in relation to the current elaboration of a new definition of social sustainability by Missimer (2015).

3. Rational for a framework like the FSSD

To achieve societal changes at a scale and rate that are needed for sustainability to even be a possible outcome, we believe it is necessary to establish a thorough understanding, not the least among leaders, of the character, magnitude and urgency of the sustainability challenge as well as the self-benefit of competent proactivity for sustainability. We also believe that concrete methodological support for such proactivity is needed. This is further elaborated on in the following sections.

3.1. Understanding the challenge and the self-benefit of proactivity

Today many leaders recognize climate change, shrinking biodiversity, poverty, erosion of trust, and several other problems. However, they typically do not know how the many problems are in fact symptoms rooted in a few overriding mechanisms of destruction of our ecological and social systems, and with that they miss opportunities for solutions that do not cause new and sometimes worse problems. An insufficient understanding of basic causes typically results in an underestimation of the true magnitude of challenges, including the momentum of ongoing unsustainable practices, and thus the urgency for actions. Although some problems are noted and recognized, they may not be seen as sustainability problems, but rather as 'ordinary' environmental and societal problems that can be dealt with later or even accepted as a 'cost' that is overweighed by the 'benefit' gained from the ongoing practices. If it is not realized that the observed

problems are in fact symptoms of an inherently unsustainable basic design and mode of operation of society, and are thus indicators of a systematically decreasing potential for the wellbeing of humanity, the challenge is underestimated and possibilities for 'root solutions' are missed.

Parallel to understanding the full challenge, it is also essential, not the least for leaders, to understand the potential self-benefit of proactivity. It may not be obvious to organizations[1] that contribute relatively more than others to unsustainability that they run relatively higher economic risks. However, the 'business case of sustainability'[2] is also about understanding how an increasingly sustainability-driven market, including policy measures, will evolve – survival issues are convincing in the end – which implies new innovation opportunities and possibilities for new markets and new market shares.

The FSSD has been designed to promote a thorough understanding of both the full scope of the sustainability challenge and the related opportunities.

3.2. Benefits of a structuring and inter-relational model

In strategic planning, one should distinguish the definition of the goal of the planning and the process by which it is approached. This distinction has long been practiced by military (e.g. Clausewitz, 1832) and civilian (e.g. Mintzberg et al., 1998) strategic planners. Furthermore, principles describing the goal should be distinguished from scientific laws and relations describing the basic functioning of the system and other aspects of the system. Also, various methods, tools and other forms of support for the planning and change process have a different character than the above mentioned two categories. In addition, guidelines for how to choose and compose actions towards the goal, as well as the actual plan of actions (the strategic plan), also have different characters. In the sustainability context, much confusion may be avoided and many benefits gained from a structuring model, clarifying the differences and interrelationships between the above (Robèrt, 2000; Robèrt et al., 2002).

The FSSD has been designed for this purpose.

3.3. Criteria of a unifying operational definition of sustainability

As indicated already, while leaders in science, business, and governments may emphatically endorse the need for sustainability, they need a language to bridge their subcultures (Kates et al., 2001). We argue that an essential part of such a language is a common definition of sustainability. How could we otherwise coordinate collaboration across disciplines and sectors while avoiding creating new problems for each problem solved, and instead design problems out of the system in a strategic way?

We have a balance to strike when it comes to such a definition. A detailed definition would be difficult for many people to agree upon and, in any case, unwise to lock our minds onto, considering the myriad possibilities that exist for sustainable futures. This is further described in the next section. On the other hand, it cannot be at such a high philosophical level that it becomes diffuse or vague, as it would then not aid the needed analyzes, innovation and cross-disciplinary and cross-sector collaboration. Furthermore, it needs to be independent of scale and context.

If principles are to be unifying across disciplines and sectors in this way, and thus operational for systematic backcasting planning and redesign for sustainability, the principles must be (e.g. Ny, 2009):

- **Necessary**, but not more to avoid imposing unnecessary restrictions and to avoid confusion over elements that may be debatable;
- **Sufficient**, to avoid gaps in the thinking, i.e., to allow elaboration into second and higher orders of principles from a complete base;
- **General**, to be applicable on any arena, at any scale, by any member in a team and all stakeholders, regardless of field of expertise, to allow for cross-disciplinary and cross-sector collaboration;
- **Concrete**, to actually guide problem solving and innovation, i.e., redesign through step-by-step approaches in real life;
- **Non-overlapping**, to enable comprehension and facilitate development of indicators for monitoring of progress.

The sustainability principles of the FSSD have been derived with these criteria in mind.

3.4. Benefits of backcasting from principle-framed visions

Forecasting and backcasting represent two major approaches to support planning and decision making. Forecasting projects current trends into the future and is often used in attempts to predict and solve problems (e.g. Dreborg, 1996; Robèrt, 2000). Unfortunately, it often leads to 'path dependencies' (e.g. Robèrt, 2000; Hukkinen, 2003) and is not appropriate when planning for long term and novel goals in complex systems and when the dominating trends are themselves a main part of the problem. For such planning endeavors, backcasting is a more appropriate approach (e.g. Dreborg, 1996; Robèrt, 2000). Backcasting begins by defining the vision, and then asks: what shall we do today and subsequently to get there (e.g. Robinson, 1990; Dreborg, 1996; Robèrt, 2000)? Semantically, one is 'backcasting' from the future situation to the present. However, when exploring early steps of optional paths to the vision, it is often useful to do simulations of likely implications of different choices in the shorter term, to support decisions regarding, e.g., in which order measures should be taken. The same is true at successive re-assessments of the plan towards the vision. This can be seen as a form of forecasting, considering but not locked by the current trends. The forecasting then takes place within an overarching backcasting approach (e.g. Ny, 2009; Broman et al., 2013).

One can backcast in different ways and for different purposes. One way is to develop a relatively detailed scenario, e.g., an image of 'a defined sustainable energy system'. Planning towards detailed scenarios, without having an understanding of a principled definition of sustainability that frames the visions, has at least four potential shortcomings:

- Considering that people have many different values and preferences, it may be difficult for large groups to agree on relatively detailed descriptions of desirable distant futures. If it is perceived that nothing can be agreed upon, there is a high risk of indifference and inactivity.
- It is difficult to know whether any given scenario is truly sustainable or not if it is not framed by and assessed against a principled definition of sustainability. While specific initiatives and actions can have beneficial impacts, without proper framing, the likelihood of unintended negative consequences is significant.

[1] In this paper we use 'organization' in a wide sense to represent any group of people that have a shared purpose, such as a company, a municipality, a regional or national government, a non-governmental organization, etc.

[2] In line with the wide interpretation of 'organization' above, the 'business case of sustainability' is not strictly reserved to business but should be interpreted as the 'self-benefit' of any type of 'organization'.

- It is difficult to achieve transferability of elements from one scenario based plan to another scenario based plan, i.e., it is difficult to draw general conclusions and gain learning from one project, topic or organization that could be relevant and useful for other projects, topics and organizations.
- With the technological and cultural evolution, which continuously change the specific conditions in a way that cannot be predicted in detail and thus change the 'optimal' vision and route ahead, it may be unwise to lock on specific targets prematurely. What might currently be seen as a specific optimal final solution, might be seen as completely obsolete later. A principle-based vision is more flexible than a scenario-based vision, since success can be achieved in a many ways within the frame of the principles, and organizational learning scholars have observed that such constraints stimulate creativity (e.g. Senge, 2003).

Consequently, we argue that backcasting from visions framed by a principled definition of sustainability is a more generic, intuitive, and practical approach for supporting sustainable development.

The FSSD has been designed for this purpose.

3.5. Theoretical benefits

With a framework having the characteristics described above, it should theoretically be possible to obtain the following benefits.

1. **The true character of the challenge and the self-benefit of proactivity should become clearer**. Clarified basic causes of experienced problems usually results in a deeper understanding of the challenge at hand and also provides a foundation for finding true solutions. In turn, understanding the challenge and the opportunities for true solutions better than 'competitors' should also imply advantages from a self-benefit perspective.
2. **The sustainable potential of various materials and practices should become possible to assess**. If one does not know how to define the frame of a vision, one cannot even attempt to estimate sustainable potentials and degrees of freedom within the frame. But with such a definition, the planning and decision making could be supported by a scientific estimation of the sustainable potential of various materials and practices, using, e.g., physics and ecology to estimate the future sustainable potential of various technologies.
3. **Trade-offs should be possible to manage strategically**. Advantages and disadvantages often relate to different parameters and variables and have different units. Analyzing the either/or of snapshots has limited strategic value. However, if one knows the frame for any vision, various options could be evaluated for their capacity to serve as stepping stones towards a situation where the trade-off dilemma at hand does not exist anymore. Optional routes could be modeled in relation to complete success, rather than evaluating snapshots in terms of good or bad within the constraints of the current reality.
4. **System boundaries setting should be possible to guide by the purpose of reaching sustainability**. Science demands clear and adequate system boundaries when systems are studied. Sustainability discourses often come with debates around where to draw the system boundaries. "Do you mean the factory, or do you include clients? Supply chains? Other stakeholders? The whole world?" When it comes to sustainability, the whole world does count, to some level of detail. Again, basic principles framing a vision should provide a way forward. Asking what, in the whole world, needs to be taken into account to make the organization support global society's compliance with sustainability principles, would inform decisions on system boundaries.
5. **Collaboration across disciplines, departments, organizations, and sectors should be possible to facilitate better**. With a principled definition framing a vision, each expert group could become better in drawing the relevant knowledge as regards challenges and optional solutions from their respective disciplines. And, representatives of each sector of society that needs to be taken into account and needs to contribute to the transition towards the sustainable vision could be brought in. The common principled framing would allow for identification of common challenges, possible synergies and coordinated collaboration over sectors so that actions in one sector support, or at least do not prevent, what needs to happen in other sectors for reaching sustainability.
6. **Unknown problems should be easier to avoid**. By re-designing with respect to basic principles for sustainability, it would not be necessary to learn about and address all the detailed consequences from a particular practice. For example, one could avoid contributing to increasing concentrations of various substances in natural systems, without knowing exactly what further increases in such concentrations may imply at certain (often unknown) thresholds.
7. **Selection, development and combination of other forms of support should be possible to guide better**. A principled sustainability definition, fulfilling the listed criteria, and a structuring inter-relational model, would make it possible to make better use of other frameworks, concepts, methods, tools, and other forms of support for sustainable development. This could happen by guiding selection among existing support that are necessary for reaching the sustainable vision, by identifying a need for development of new support and by guiding a combined use.
8. **Education and research for sustainable development should be possible to guide and organize better**. Just as collaboration across disciplines, and a structured overview of frameworks, concepts, methods, tools, etc., should be facilitated by a common definition of sustainability and an inter-relational model, this should be useful also for structuring and organizing education and research, putting different subjects in the context of, and to the service of, sustainable development in a cohesive way.

4. The framework for strategic sustainable development

The FSSD has been developed, and continues to be evolved, in response to the rational for such a framework presented in Section 3. As seen in Section 2, this has been an iterative learning process. Some of the insights and benefits presented in Section 3 have appeared parallel to the development of the framework, although the presentation is linear in this paper.

The FSSD comprises the following main features, each described in the following sections:

- A funnel metaphor facilitating an understanding of the sustainability challenge and the self-benefit of competent proactivity.
- A five-level structuring and inter-relational model distinguishing and clarifying the inter-relationships between phenomena of fundamentally different character.
- A principled definition of sustainability useful as boundary conditions for backcasting planning and redesign for sustainability.
- An operational procedure for creative co-creation of strategic transitions towards sustainability.

4.1. The funnel metaphor of the FSSD

The systematic decline of the ecological and social systems' potential to support the fulfillment of human needs, in combination with the growing population, can be metaphorically illustrated as the human civilization entering deeper and deeper into a funnel. See Fig. 1. The decreasing potential is represented by the decreasing cross-section as we enter deeper into the funnel. The inclined funnel wall illustrates the systematic character of the challenge. It is not that we have a compressed cylinder, representing environmental and societal problems to certain degrees and that may come and go. Instead, the overall situation gets worse and worse at the global level, so it is questionable to weigh the problems against related benefits of current practices and in democratic processes based mainly on peoples' current values and preferences. The decreasing potential comes out as an unavoidable result of the current basic design and mode of operation of society (violating basic sustainability principles), and is thus systematic and implies unsustainability. When the unsustainable basic design and mode of operation of society have been resolved (no more violation of sustainability principles) the funnel turns into a cylinder, implying sustainability. Note, however, that this does not mean that there are no problems whatsoever. Also in a sustainable society there will be accidents, crime, pollution, loss of species, etc. We are not trying to find a recipe for utopia. What must be achieved, however, is a stop to the systematic decline of the foundation for the human civilization. Then, in the longer term this potential might be increased again through restorative actions, allowing for higher prosperity and degrees of freedom in a sustainable future, which is illustrated by the increasing cross-section of the funnel to the right in Fig. 1.

The funnel metaphor is particularly useful for illustrating the self-benefit of proactivity for sustainability in today's situation, and thus to get the attention of leaders. Actors who contribute relatively more than others to unsustainability run relatively higher risks of hitting the wall of the funnel, over and above those attributed to the destruction of our global habitat that will affect us all in the end. The funnel wall will be experienced as, sometimes abrupt, changes in legislation, regulation and tax, resource availability and resource costs, insurance and credit costs, waste management costs, and, not the least, changes in customer and employee preferences and risks of losing out to competitors that navigate the paradigm shift more skillfully. It is wiser to invest in developments towards the opening of the funnel than into its wall. The business case of sustainability is not only about traditional risk and cost reductions but also about understanding the inevitable dynamics of the funnel and how an increasingly sustainability-driven market will evolve as a result the funnel. Intuitively, the main self-benefit from doing good for the whole system probably comes from capturing of innovation opportunities, from exploration of new markets and from winning of new market shares, in addition to reducing direct risks and costs.

Each actor needs to strike a balance. Being too proactive implies risks of not getting sufficiently high or timely returns on investment. On the other hand, simply reacting to changes in legislation, regulation and changes of tax also imply great economic risks, linked to falling behind competitors. There is a business case of sustainability to some degree for most actors, regardless of what other actors do. What other actors do only influences the pace of the change. A particularly interesting aspect is that proactive companies might actually turn to politicians and ask for harsher legislation, regulation or tax, with the purpose of increasing the general pace of change and at the same time gain relative advantages for themselves. For example, if a company has already developed pilot products that are well ahead of the current legislation and regulation or less sensitive to increased tax (e.g. on fossil fuels), and that can be scaled up to replace a major part of their

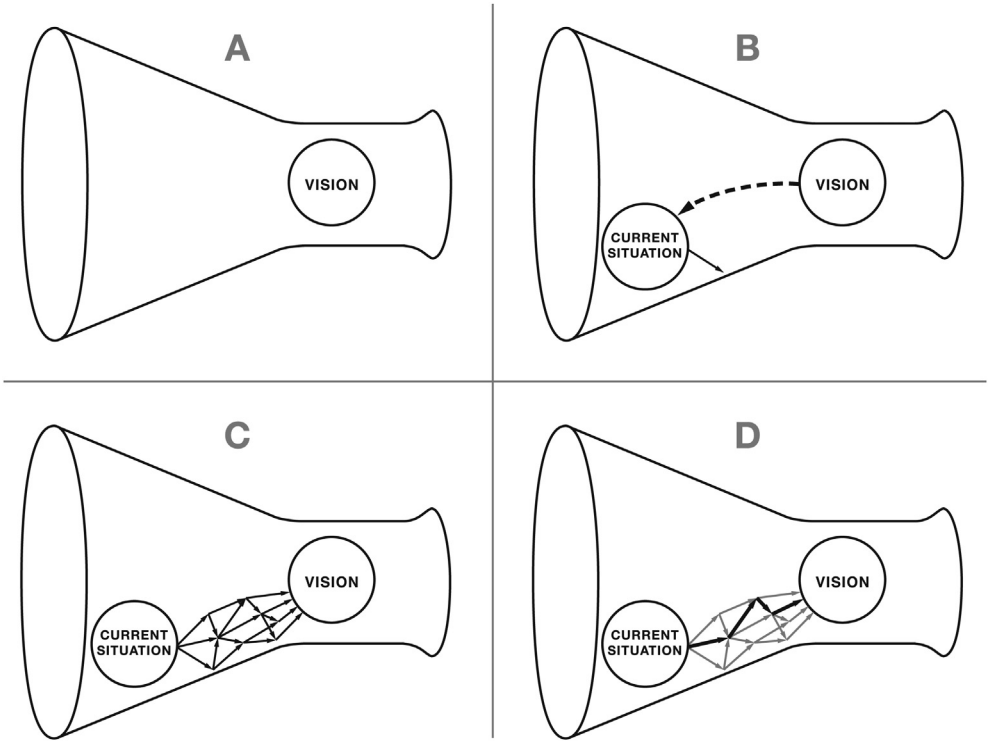

Fig. 1. The funnel metaphor and the ABCD-procedure of the FSSD. The inclined funnel wall clarifies the systematic character of the challenge as well as the self-benefit of having and working towards a sustainable vision (avoiding hitting the wall of the funnel while moving to the vision in the opening of the funnel). A sustainable vision is captured in (A). The current challenges and assets in relation to the vision are captured in (B). Possible steps towards the vision are captured in (C), and these are prioritized into a strategic plan in (D).

product range, they might assess that harsher legislation, regulation or tax will hit their competitors harder than themselves. Several FSSD-knowledgeable leaders have acted on this possibility vis-à-vis Swedish and European politicians. Examples include the top managements at OK Petroleum and the Volvo Group asking the Swedish government for higher tax on fossil fuels and carbon dioxide emissions, respectively, Electrolux asking the Swedish government for a ban on heavy metals in batteries, and IKEA lobbying in the European Union for a more demanding regulation of chemicals (REACH).

For a further discussion of the business case of sustainability, see, e.g., McNall et al. (2011), Willard (2012), and Robèrt and Broman (2015).

Once the sustainability challenge and the potential self-benefit of proactivity are realized in principle, concrete support for acting on this insight is required. It is necessary to structure the thinking, to understand more specifically what causes the narrowing funnel and how the opening of the funnel can be defined, and to have an operational procedure for the creation of strategic plans. This is what follows in the next sections.

4.2. The five-level model of the FSSD

To clarify differences and inter-relationships between entities of different character in the sustainability context, the FSSD comprises a model of the following five levels.[3]

1. System	The system level includes principles for the functioning of the global system, i.e., the human society within the biosphere, and our knowledge on resource stocks and flows, biogeochemical cycles, assimilation capacity, climate regulation capacity, biodiversity, resilience, the basic constitution of human beings, trust between people and between people and societal institutions, etc., and known relationships between human practices and impacts in the ecological and social systems. For a specific organization, its dependence on the general regional and global support systems as well as how it is nested in value chains and other stakeholder networks and how it is affected by unsustainability impacts also belong to the system level. As an analogy, in chess, the system level includes the board and its constitution, the different pieces and the rules for how they can be moved.
2. Success	The success level includes the definition of the vision. The FSSD requires any vision to be framed by basic sustainability principles. Why aspire for a vision that cannot be in the future? For a specific organization, additional success criteria in the form of core purpose, core values and overall 'end-goals' specific to the organization can be added. Besides the sustainability principles, the FSSD is non-prescriptive. A multitude of possible visions exist within the principled frame. Relating to the chess analogy, there are almost uncountable combinations fulfilling the few basic principles of checkmate. When a vision has been defined it can guide supplementary studies of the system (including what need not to be studied), as well as selection, combination and development of supplementary forms of support as needed to enable the transition.
3. Strategic guidelines	The strategic guidelines level includes guidelines for how to approach the principle-framed vision strategically. The FSSD provides a number of generic guidelines for stepwise transitions. For a specific organization, additional guidelines can be added depending on the context. Besides the obvious that actions should be selected and combined based on their capacity to serve as economically viable platforms towards the vision, ensuring that resources continue to feed the process all the way, the FSSD is non-prescriptive. A multitude of viable routes towards any sustainable vision exist. Referring to the chess analogy, there are almost uncountable possible routes towards checkmate.
4. Actions	The actions level includes the concrete actions that have been prioritized by the specific organization into a strategic plan, using the strategic guidelines and the vision to inspire, inform, and scrutinize the possible actions. Examples of actions in the sustainability context may include sustainability education of staff, phasing out certain substances, introducing certain procurement practices, phasing out non-renewable energy sources, requiring certain working conditions throughout the value chain, etc. The strategic plan is re-assessed repeatedly as the specific contextual conditions change and learning takes place with time as the development unfolds.
5. Tools	The tools level includes methods, tools and other forms of support that are often required for decision making, monitoring, and disclosures of the *actions* to ensure they are chosen in line with the *strategic guidelines* to arrive step-by-step at the defined *success* in the *system*. Examples in the sustainability context include modeling, simulation, life cycle assessment, management systems, indicators, etc.

It is the rigor by which the first three levels are described that determines how confident an organization can be when choosing appropriate actions and appropriate forms of support such as various tools (Robèrt, 2000; Robèrt et al., 2002, 2013a). The second level stands out as particularly critical and is elaborated in the next section.

[3] A model with these five levels is useful in any context and for planning and acting towards any success definition. It is then simply called the (generic) 'five-level model'. In the FSSD it is applied for the purpose of supporting sustainable development.

4.3. The sustainability principles of the FSSD

In many planning processes the success level is often either too detailed, such as when a specific and static scenario is used for backcasting, or not operational enough, such as when only Brundtland's principled definition is used (see below). To be useful in practice for backcasting planning and redesign for sustainability, the definition needs to be generally applicable and still sufficiently concrete to guide analyzes, innovation, planning, and selection, development and a coordinated use of supplementary methods, tools and other forms of support.

From the driving question behind the FSSD development it is obvious that we think a single (unifying) science-based definition of sustainability is appropriate and necessary. However, before presenting what we believe is such a unifying definition, we should point out that the attempt for a science-based definition of sustainability starts from a normative stance. The Brundtland definition (World Commission on Environment and Development, 1987) can be taken as such a value statement to depart form: We want for humanity: "… *development that meets the needs of the present without compromising the ability of future generations to meet their own needs*." This *want* cannot be derived from scientific knowledge or proven right by scientific methods. Seeing this as something desirable is a normative stance.

Furthermore, a society where all people have all their needs fulfilled all the time is utopia. However, humanity can hold this as an ideal state that should not be continuously deviated from, since such a systematically increasing deviation implies unsustainable development. Once this normative stance is accepted, scientific knowledge and scientific methods can be used to draw conclusions: if this is what we want, on what conditions can it be achieved? As human beings generally have, by constitution, a desire to satisfy their needs, sustainability is about not having systematic obstacles for people to do so. So, what are the essential aspects of the ecological and social systems that need to be sustained in order to not systematically undermine the capacity of people to meet their needs, now and in the future, and what are the overriding mechanisms by which these essential aspects can be degraded?

From our studies of the ecological system and dialogues with natural scientists we have concluded that essential aspects that need to be sustained include, e.g., assimilation capacity, purification capacity, food production capacity, climate regulation capacity, and diversity (e.g. Steffen et al., 2004, 2015). From our studies of the social system and dialogues with social scientists we have concluded that essential aspects that need to be sustained include, e.g., trust between people and between people and societal institutions, diversity of personalities, ages, gender, skills, etc., common meaning, capacity for learning, and capacity for self-organization (Missimer et al., 2015a).

Now finding out by what primary mechanisms, upstream at the first level in chains of causality, humanity can degrade these essential aspects systematically, and then inserting a 'not' for each mechanism of destruction, yields first-order sustainability principles, as exclusion criteria for redesign. As mentioned in Section 2, it is continuously also tested that contemporary sustainability issues are all covered by and can be easily clustered under the different sustainability principles. This has revealed how myriad downstream impacts are rooted in a few upstream errors of the basic societal design and mode of operation.

The current phrasing of the sustainability principles of the FSSD is as follows (e.g. Robèrt et al., 2013a; Missimer, 2015):

In a sustainable society, nature is not subject to systematically increasing …

1. … *concentrations of substances extracted from the Earth's crust.* This means limited extraction and safeguarding so that concentrations of lithospheric substances do not increase systematically in the atmosphere, the oceans, the soil or other parts of nature; e.g. fossil carbon and metals;
2. … *concentrations of substances produced by society*. This means conscious molecular design, limited production and safeguarding so that concentrations of societally produced molecules and nuclides do not increase systematically in the atmosphere, the oceans, the soil or other parts of nature; e.g. NO_x and CFCs;
3. … *degradation by physical means*. This means that the area, thickness and quality of soils, the availability of fresh water, the biodiversity, and other aspects of biological productivity and resilience, are not systematically deteriorated by mismanagement, displacement or other forms of physical manipulation; e.g. over-harvesting of forests and over-fishing;

and people are not subject to structural obstacles[4] to …

4. … *health*. This means that people are not exposed to social conditions that systematically undermine their possibilities to avoid injury and illness; physically, mentally or emotionally; e.g. dangerous working conditions or insufficient rest from work;
5. … *influence*. This means that people are not systematically hindered from participating in shaping the social systems they are part of; e.g. by suppression of free speech or neglect of opinions;
6. … *competence*. This means that people are not systematically hindered from learning and developing competence individually and together; e.g. by obstacles for education or insufficient possibilities for personal development;
7. … *impartiality*. This means that people are not systematically exposed to partial treatment; e.g. by discrimination or unfair selection to job positions;
8. … *meaning-making*. This means that people are not systematically hindered from creating individual meaning and co-creating common meaning; e.g. by suppression of cultural expression or obstacles to co-creation of purposeful conditions.

The sustainability principles have been developed and continues to be refined to come as close as possible to compliance with the criteria discussed in Section 3.3, i.e., 'necessary', 'sufficient', 'general', 'concrete', and 'non-overlapping'. This definition of sustainability sets the basic conditions that are necessary to fulfill for the ecological and social systems to not degrade systematically. They constitute the boundary conditions within which society can continue to function and evolve, outside of which it cannot.

The relations between the Brundtland definition, the essential aspects of the ecological and social systems and the above sustainability principles are schematically summarized in Appendix A.

By use of 'not contributing to', an individual organization can utilize these global sustainability principles to guide decisions and behavior. For example, the first principle is translated into: 'When our organization is sustainable, it does not contribute to systematically increasing concentrations in nature of substances extracted from the Earth's crust.' In a globally sustainable society, no actor contributes to violations of the sustainability principles.

Being able to structure reality and having a principled definition of sustainability are crucial, but not enough, for sustainable development. A procedure for pragmatic leadership and co-creation is also needed. This is elaborated in the next section.

4.4. The operational procedure of the FSSD

The FSSD comes with an application procedure in organizations for creative co-creation of strategic transitions, i.e., a procedure that supports execution of backcasting planning and redesign for sustainability. This so-called ABCD-procedure comprises four general steps as follows:

A. In this step, participants learn about the sustainability challenge and related opportunities (e.g. the funnel metaphor), and the FSSD in general, including this ABCD-procedure. They share and discuss the subject of the planning endeavor and agree on a *preliminary* vision of success, framed by the basic sustainability principles. The vision may include the organization's core purpose, core values and overall 'end-goals' to a level of specificity that is felt relevant and can be agreed upon. If such goals or designs are discussed, these are analyzed with regard to their overall potential in relation to the sustainability principles, rather than in relation to constraints implied by the current reality (see also C).
B. In this step, participants analyze and assess the current situation of the organization in relation to the vision and list current challenges as well as current assets to deal with the current challenges or that can in other ways potentially support the transition towards the vision. In particular, the analysis and assessment should reveal how in concrete terms

[4] By structural obstacles we mean social constructions – political, economic and cultural – which are firmly established in society, upheld by those with power (political, economic or other forms), and which are, due to a variety of dependencies, difficult to overcome or avoid by the people exposed to them (Missimer et al., 2015b).

the organization contributes to society's violation of the sustainability principles and how current assets contribute or could contribute to society's compliance with the sustainability principles. At this point, identifying relevant subsystems and their inter-related nature will allow for coordinated development, such that solutions within each subsystem can be supportive of solutions in other subsystems, or in any event not be counter-supportive.

C. In this step, participants apply creativity methods such as brainstorming to identify possible solutions to the challenges and for capturing of the opportunities implied by the gap between the vision established in (A) and the current reality established in (B). All possible actions that can help closing the gap are listed, including ideas for how to utilize the existing assets listed in (B). The ideas generated are scrutinized only with respect to the vision within the sustainability principles. Constraints implied by the current reality, e.g., the current infrastructure, energy system, stakeholder dependencies, financial capacity, etc., are temporarily disregarded. Just because an action is not feasible immediately, does not preclude it as a viable step later in the transition. During this C-step, additional overall 'end-goals' may come up and can then be added to the vision, or the goals already there might be adjusted based on the new ideas. For a discussion on dematerialization and substitution as examples of broad and dynamically interrelated approaches to addressing sustainability challenges at the C-step, see, e.g., Robèrt et al. (2002, 2012).

D. In this step, participants apply strategic guidelines to prioritize among the possible solutions established in (C) into a strategic plan. The most basic guidelines imply that early steps should be (1) flexible platforms for forthcoming steps that, taken together, are likely to support society's transition towards sustainability and take the organization to the sustainability-framed vision, while striking a good balance between (2) the pace of progress towards the vision and (3) return on investment. The guidelines must be combined. Otherwise, an actor might, e.g., run out of financial resources and find its competitive position diminished (Esty and Porter, 1998), or select actions that give quick wins but then turn out to be suboptimized in the longer perspective (Broman et al., 2000; Holmberg and Robèrt, 2000). It is only in the context of coming steps and the identified gap to the vision that an action can be evaluated in a meaningful way, not in isolation. For a further discussion on prioritization, see, e.g., Robèrt et al. (2012, 2013a). For a discussion on additional strategic guidelines, such as transparency, accountability, etc., see, e.g., Robèrt et al. (2002) and Missimer et al. (2015b).

Often, all of this both requires and facilitates collaboration across disciplines and sectors. It also allows and facilitates for values and preferences to be weighed against each other in a strategic dialogue and in relation to a science based foundation.

In this context, the option of making no change deserves a comment. First, such a decision requires as much consideration as a decision to make a change. Second, it is not necessarily a bad thing. It might be a good decision to make no change in a specific area in the short term. For example, it might be wise to go on with the current technology as is, yet for some years, and await a new technology that is about to have a breakthrough, rather than making big investments in marginally improving what will likely soon be entirely obsolete. The latter comes with significant risks. Again, any option, whether it implies an active change or not, should be evaluated for its possibility to serve as a viable platform towards the sustainability-framed vision.

Although described in a linear fashion, the ABCD-procedure is more of an iterative process. There is a general motion from A to D, as there is a general motion from level 1 to level 5 of the five-level model, and the *main* focus of attention may be in one of these steps and levels at a time. However, to some degree the users also have 'flashes of thoughts' going to the other steps and levels all the time, as well as to previous experience. For example, as indicated above, although a vision has been established (level 2; step A), the users may discover a desire to adjust that vision when brainstorming (C), which, in turn, may call for a more elaborate outline of the system (level 1). The users may, e.g., realize that a more thorough mapping of the organization's value chain is needed, which may require certain tools (level 5). Likewise, when prioritizations are done (D), some users may realize that there is a challenge that was previously missed, which is then added to the B-list. Etc. Our experience from applying the ABCD-procedure in real-life is that such 'ping-ponging' and 'flashes of thoughts' happen all the time. The flow should be encouraged by facilitators of the FSSD-work and not interrupted, e.g., by an isolated focus on one step at the time. Our brains work best if allowed to associate freely, while putting the results where they belong in a logical structure. Facilitators might also need to repeatedly remind participants to utilize the benefits of a framework of this type (Sections 3.5 and 5) and guide them how to do it. For example, when considering significant investments in various technologies; always evaluate their future sustainable potential by modeling them within the frame of the sustainability principles, when trade-offs need to be handled; always evaluate proposed actions for their capacity to serve as stepping stones towards a situation where the trade-off dilemma at hand does not exist anymore, when cross-sector collaboration is facilitated; always compare ABCD-notes across the sectors. Etc.

We should also point out that various supplementary methods, tools and other forms of support (level 5) can be useful in all steps of the ABCD-procedure. For example, in the A-step modeling and simulation tools can be used to facilitate learning, in the B-step they can support the analysis of the current situation, e.g., by clarifying orders of magnitude of various contributions to societal violations of the sustainability principles, and in the C-step they can aid creativity for generating possible solutions. In the D-step, such tools can be used for 'what-if-simulations' to compare alternative actions and aid prioritization. It is also during the ABCD-procedure the gap to full sustainability becomes clearer and clearer, as does solutions and prioritizations. This enables appropriate selection, combination and identification of needs to develop supplementary support, including indicators, for facilitating and monitoring the change. The opposite; taking a specific tool, e.g., a specific predefined set of indictors, as the foundation for the organization's sustainability work is not recommended. For a further discussion, see, e.g., Robèrt et al. (2002, 2012).

Finally, when a strategic plan has been established, all of the above need to be repeated. The progress and the contextual conditions need to be monitored continuously and the remaining actions in the plan need to be re-assessed accordingly. Using the chess analogy again, it is not wise to stick to the first plan while disregarding the opponent's moves.

The ABCD-procedure is schematically illustrated, together with the funnel metaphor, in Fig. 1.

5. Experienced benefits of the FSSD

In the following we reflect on application examples and discuss how the theoretical benefits of a framework like the FSSD

presented in Section 3.5 have actually been observed in practice. Usually several benefits have been seen in each example, and more examples exist, but the purpose of this paper is not to give a complete review.

1. The true character of the challenge and the self-benefit of proactivity become clearer. The FSSD has contributed to a profound change in the world-view of many leaders, both with regard to challenges and opportunities, and has led to profound changes in the way they have led their organizations. We have seen how it helps leaders understand that sustainability is not one of many 'extras' trying to make its way into their organizations but in fact a necessity to be knowledgeable about for successfully leading their organizations. The FSSD typically serves as an eye-opener and door-opener to executives and other leaders. Many bear witness about this and the first examples came from Sweden and leaders in companies such as IKEA, Electrolux, Scandic Hotels, Swedish McDonalds, etc. (e.g. Robèrt, 2002).

The first international example is Ray C. Anderson, former CEO of Interface (e.g. Anderson, 2011). Anderson invented a 'story' within the company to communicate backcasting from sustainability principles. The whole endeavor of eventually becoming sustainable was named "*Mission Zero*" and he metaphorically compared it with climbing a mountain higher than Mount Everest, namely "*Mount Sustainability*". The top of the mountain was defined as complying with the sustainability principles of the FSSD (zero violation). The strategies followed naturally; to gradually move away from fossil feed-stocks to energy and materials, chemicals that risk accumulating in natural systems, sourcing from poorly managed ecosystems, etc. The business case of this was clearly understood and articulated in many contexts. For example, Anderson said in Portland in October 2007: "*As we climb Mount Sustainability […] we are doing better than ever on bottom line business. This is not at the cost of social or ecological systems, but at the cost of our competitors who still haven't got it.*" Various aspects of the Interface case has also been described in many other publications (e.g. Stubbs and Cocklin, 2008a, 2008b; Boons and Lüdeke-Freund, 2013; Lindahl et al., 2014).

2. The sustainable potential of various materials and practices becomes possible to assess. Several FSSD informed estimates of sustainable potentials of various materials and practices exist. For example, in the early 1990s the management team of the company Electrolux realized from an FSSD analysis that chlorofluorocarbons (CFCs) had a very low potential for sustainable use in their products (household white ware). At large scale use in consumer goods it is technically and economically extremely difficult to prevent these relatively persistent and foreign to nature chemicals from increasing systematically in concentration in nature (high risk of violation of sustainability principle 2). Consequently, Electrolux decided to phase such chemicals out, and did so in a strategic way (e.g. Robèrt et al., 2013a; Lindahl et al., 2014). See also item 6 below. Understanding the FSSD also led Electrolux to think about their use of metals. The CEO at that time, Leif Johansson, asked for indications of various metals' relative risk of violating sustainability principle 1 of the FSSD. A table with such indicators was presented by Azar et al. (1996), which influenced Electrolux's metal strategies.

3. Trade-offs can be managed strategically. Assessing trade-offs primarily with regard to the different alternatives' potential to serve as smart stepping stones towards the full scope of sustainability as defined by the sustainability principles, and not mainly as choices between evils in the short term, is at the heart of the FSSD. This has been thoroughly described in relation to many examples (e.g. Broman et al., 2000; Robèrt et al., 2013a; Lindahl et al., 2014).

A recent example is Aura Light's introduction of Light Emitting Diodes (LEDs) in some of their products. LEDs do not include mercury and are even more energy efficient than the company's other low energy and long-life light sources. These characteristics certainly imply a potential for improved sustainability performance. However, using FSSD thinking, Aura Light is well aware that today's LED solutions are far from sustainable for large scale use and along existing business models. The remaining sustainability challenges can be rational trade-offs in relation to the benefits of introducing LEDs already now on the condition that current LED solutions can serve as viable steps towards the full scope of sustainability. Aura Light has set out to explore strategies by which the scarce metals included in LEDs today, as well as phosphates, can be tightly recycled. It is likely not technically and economically feasible to avoid significant contribution to violation of sustainability principles through traditional recycling of customer owned products. Therefore, Aura Light is exploring new business models built on Light as a Service, where the ownership of the physical products remains with Aura Light, to facilitate control of the materials (Franca et al., in this issue). In parallel, research on LEDs including metals or other materials that are less problematic from the sustainability principles' point of view are closely followed.

4. System boundaries setting can be guided by the purpose of reaching sustainability. This benefit is implied by the way organizations use the sustainability principles to inform their analyzes, envisioning processes and transitions. As explained above, an individual organization 'translates' the sustainability principles by the use of 'not contributing to' unsustainability globally. This implies a rational way of guiding system boundaries setting. By combining knowledge of the organization's activities and the lens provided by the sustainability principles, it can be estimated which the most significant aspects are, and the relevant system boundaries for specific analyzes of these aspects can be set. For example, a company's direct influence on social sustainability issues might be quite local or highly global depending on the company's value network. The system that is necessary to consider might also be different for different aspects even for one and the same organization. Our experience from working with companies, municipalities and other organizations is that they learn quickly to identify and handle relevant arrays of subsystems.

As an example, the bakery group Polarbröd sources their agricultural raw products from Sweden, northern Finland, to some extent Germany and for seeds used in some breads, outside of Europe. So, for these different raw products, different subsystems (and spheres of influence) are relevant for Polarbröd's sustainability impact analyzes. Considering suppliers of suppliers, e.g., farmers sourcing fertilizers from other parts of the world, yet other subsystems need to be considered. Polarbröd uses the FSSD to guide their collaboration with suppliers of agricultural raw products and map out supply chains, related sustainability impacts and possibilities for joint development towards sustainability. As regards Polarbröd's electricity use the most relevant system is the European electricity system, since the Swedish electric grid is part of the interconnected European grid. As the marginal electricity generation in Europe is based on fossil fuels, a change in electricity demand significantly influences the total carbon dioxide emissions. Therefore, to reduce their contribution to violations of sustainability principles resulting from fossil fuel in electricity generation, Polarbröd has invested in their own electricity generation capacity based on

renewable sources to an extent that matches their whole current electricity use. Also, as they plan to phase in electric vehicles for part of their distribution of bread, they intend to invest in more electricity generation capacity based on renewable sources to match the increased electricity demand.

This way Polarbröd works with all their contributions to violations of sustainability principles identified through their continuous FSSD work and establishes the relevant system boundaries for the respective aspects. The perspective is not limited upfront to a certain predefined set of impacts or a certain predefined geographical area, but embraces all contributions to violations of sustainability principles globally. Polarbröd asks 'what in the whole world do we need to take into account as regards global society's compliance with sustainability principles', and set specific system boundaries for their specific impact analyzes regarding different aspects accordingly.

This benefit, to understand why and how it is easier to manage complexity in a non-reductionist way, starting out from the big picture purpose (sustainability globally), is regularly seen in organizations using the FSSD. This benefit is closely related to the trade-off handling described above as well as to the cross-border collaboration described below.

5. Collaboration across disciplines, departments, organizations, and sectors can be better facilitated. Also this benefit has been seen in many cases. For example, in the municipality Whistler, Canada, many stakeholders with initially strongly conflicting opinions could reach agreement on a principle-framed vision for 2020 and early steps towards the vision (e.g., Gordon, 2004; VANOC, 2010). Using a principled sustainability definition, and by assessing their respective challenges and opportunities and comparing notes in relation to this common definition, they discovered several common aspects and possible synergies, which opened up for co-creation and collaboration. Another leading example in the community context is the City of Eindhoven, the Netherlands. Philips Research, having their head-office in Eindhoven, started to use the FSSD to inform cross-disciplinary collaboration between their innovation and sustainability teams (Seebode, 2011). Philips urged the municipality to also use the FSSD to inform coordinated cross-sector work, which they did. Among other things, the FSSD is now used to inform the transition to sustainable buildings in the city (Eindhoven, 2015). For example, the FSSD informed the collaboration between five major housing corporations towards a vision of Sustainable Living, in turn influencing numerous local construction companies and architects- and engineering firms. In fact, also a new conference site was built based on FSSD thinking, in which representatives from various sectors meet regularly to apply the FSSD to identify challenges and opportunities and compare notes, all with the general aim to collaborate more effectively across sectors towards sustainability in the city.

Another example is Green Charge Southeast, one of the biggest electric vehicle projects in the world. It is a cooperative action research effort aiming at a vision and roadmap for a sustainable transport system in the southeast of Sweden. It involves researchers and regional stakeholders from many disciplines and sectors, including more than twenty companies, more than twenty-five municipalities, and several county administrative boards and regional governments. This whole multi-stakeholder effort is guided by the FSSD (e.g. Borén et al., 2015; Robèrt et al., 2015).

A significant example also comes from the European polymer industry. Early on, efforts to find conditions for sustainable Poly Vinyl Chloride (PVC) management took the form of FSSD guided multi-stakeholder dialogues, involving representatives from science, industry, authorities and NGOs. Hydro Polymers, one of the companies involved in the early dialogues, realized that their whole value chain had to be involved if sustainable management of PVC was ever to be achieved. Hydro Polymers therefore wanted their value chain members to learn about the FSSD, as a shared mental model for the collaboration towards sustainability. Hence, a university course for this purpose was co-created by Hydro Polymers, the NGO The Natural Step and Blekinge Institute of Technology (BTH). This way, many directors, product developers and other professionals in Hydro Polymers' value chain were trained in the FSSD. A cascade of actions then occurred in the industry, significantly contributing to a European wide voluntary commitment to a sustainable PVC value chain known as VinylPlus (VinylPlus, 2015). The material aspects of this example are described by Lindahl et al. (2014). A comprehensive description of the case will be given in an upcoming publication from the INSEAD business school.

6. Unknown problems can more easily be avoided. It is because humanity violates basic sustainability principles that planetary boundaries are approached and exceeded (Robèrt et al., 2013a). The FSSD allows us to move strategically towards sustainability before all specific impacts from unsustainability and their respective critical limits are known. For example, if the sustainability principles and FSSD thinking had been known and applied when CFCs were about to be introduced, the logical conclusion would have been that they should not be used in the way they have been used (large scale use in consumer products). This is obvious from what has already been said above. Without predicting the exact chain of causality, involving very complex chemistry as we know today, and the exact type and extent of impacts for certain concentrations, the ozone depletion problem could have been avoided. And actually, Electrolux used FSSD reasoning to avoid creating new problems when they phased out CFCs (e.g., Robèrt et al., 2013a; Lindahl et al., 2014). The idea of using hydro chlorofluorocarbons (HCFCs) instead of CFCs, the standard solution at that time, was abandoned as Electrolux realized that such substances too come with high risks of violation of sustainability principle 2. For the same reason hydro fluorocarbons (HFCs) were used only as a temporary flexible platform to hydro carbons (HCs). HCs were seen as the long term solution since these are reasonable to manage within the sustainability principles, and this is today the standard solution for household refrigerators and freezers in many countries. We do not need to know and we will hopefully never know what exact impacts a large scale long-lasting use of HCFCs and HFCs could cause.

7. Selection, development and combination of other forms of support can be better guided. This benefit has been seen in multiple studies informed by the FSSD. Strengths and weaknesses, and possibilities for combinations, of several methods, tools and other forms of support for sustainable development have been analyzed with regard to their ability to be helpful for an organization wanting to close the gap between the current unsustainable situation and a future sustainable situation in a strategic way. Examples of studies where this logic has been applied include Ecological Footprinting (Holmberg et al., 1999; Robèrt et al., 2002), Factor 4 (Robèrt et al., 2001), Daly's principles (Robèrt et al., 1997), ISO 14001 (Rowland and Sheldon, 1999; Robèrt, 2000; Robèrt et al., 2002; MacDonald, 2005), Life Cycle Assessment (Andersson et al., 1998; Upham, 1999; Ny et al., 2006), Zero Emissions, Cleaner Production, Sustainable Technology Development, Natural Capitalism (Robèrt et al., 2002), Industrial Ecology (Korhonen, 2004), Corporate Social Responsibility (Waage et al., 2005), Eco-Design (Byggeth and Hochschorner, 2006), Company

Decision Systems (Hallstedt et al., 2010), and Planetary Boundaries (Robèrt et al., 2013a).

A general conclusion from these studies is that there are many good frameworks, concepts, methods, tools, etc., for sustainable development. Each has its specific perspective, strengths and weaknesses. None of them, however, can replace a unifying and structuring framework. On the other hand, such a unifying framework can increase the utility of all the other forms of support by highlighting their strengths (mostly what they are designed to do) and weaknesses (mostly what they are not designed to do) and enabling them to be combined for supporting strategic approaches.

The FSSD has also been used to inform development of new methods and tools. Examples include Strategic Life Cycle Management (Ny et al., 2006), Method for Sustainable Product Development (Byggeth et al., 2007), Templates for Sustainable Development (Ny et al., 2008), and approaches to Sustainable Transport Planning (Robèrt, 2005, 2015; Borén et al., 2015; Robèrt et al., 2015).

8. Education and research for sustainable development can be better guided and organized. The FSSD is a core part of the Masters in Strategic Leadership towards Sustainability program at BTH (BTH, 2015a; Robèrt et al., 2013b). Among the appreciated traits of the program among the students are its structure and cohesiveness (Waldron et al., 2004; Missimer and Connell, 2012). The many different knowledge areas that are included are integrated and held together by the structured overview facilitated by the FSSD.

The FSSD has also been used to guide integration of sustainability in, e.g., mechanical engineering education at BTH in Sweden (Broman et al., 2002) and chemistry at Carnegie Mellon University in USA (Collins, 2015), as in several other fields at other universities. It is also at the heart of a new transdisciplinary PhD program in strategic sustainable development at BTH (BTH, 2015b).

6. Discussion

We have presented the result of a 25-year attempt at developing a unifying framework for strategic sustainable development. Key features of the framework include (i) a funnel metaphor of the sustainability challenge and related opportunities, (ii) a five-level structuring and inter-relational model, (iii) a principled definition of sustainability, and (iv) an operational procedure for co-creation of strategic transitions towards sustainability.

The development of the framework for strategic sustainable development (FSSD) is based on, and we suggest it represents, a number of breakthroughs in systems science for sustainability.

First, forecasting often leads to 'path dependencies' (e.g. Robèrt, 2000; Hukkinen, 2003) and is not appropriate when planning for long term and novel goals in complex systems and when the dominating trends are themselves a main part of the problem. For such planning endeavors, backcasting is a more appropriate approach (Dreborg, 1996; Robèrt, 2000). In the sustainability context, forecasting should therefore not be used as the only or main approach, but rather as a supplement in an explorative way within an overarching backcasting approach (e.g. Ny, 2009; Broman et al., 2013). Once the gap to a desired vision has been clarified and possible measures to close the gap identified, forecasting can be used for 'what-if simulations'. This allows for *consideration of current trends* when exploring early steps in different possible development paths, *while avoiding getting locked to those current trends*.

Second, the FSSD is built on the insight that there are myriad possible detailed designs of future sustainable societies as well as myriad possible transition routes, and that locking any major effort to a detailed image (scenario) of a future society and a fixed transition plan is therefore unwise. Instead sustainability should be defined by basic principles, allowing for flexible adoption as the development unfolds and the contextual conditions change.

Third, once the *rational* for 'backcasting from visions framed by sustainability principles' is understood, one should seek principles that meet the criteria 'necessary', 'sufficient', 'general', 'concrete' and 'non-overlapping', to be useful for backcasting planning and redesign for sustainability. It is a breakthrough that principles aimed at fulfilling these criteria have already come so close to fulfilling the criteria, and have proven useful in practice for the intended purpose.

Fourth, the five-level model of the FSSD has proven to be a useful support for structuring analyzes and assessments and for avoiding confusion in the complex sustainability context by distinguishing and clarifying the inter-relationships between phenomena of fundamentally different character.

Finally, through the combined features, including the funnel metaphor, it has been possible to establish a thorough understanding, not the least among leaders, of the full scope of the sustainability challenge as well as the self-benefit of competent proactivity for sustainability. Such proactivity has been seen in numerous examples. The seemingly incompatible has been possible to link – small scale with big scale, short term with long term, and profitability with ethics.

Many examples of application clearly show that the FSSD aids a thorough understanding of the sustainability challenge and related opportunities and concretely aids organizations in moving strategically towards sustainability, i.e., to stepwise reduce their negative impacts on ecological and social systems at large while strengthening the own organization through capturing of innovation opportunities, including new business models, exploration of new markets and winning of new market shares, and reduced risks and operation costs. Specifically, the application examples have shown that the FSSD aids more effective management of system boundaries and trade-offs, makes it possible to model and assess sustainable potentials for various materials and practices before investments are made, and offers the possibility for more effective collaboration across disciplines and sectors, regions, value-chains and stakeholder groups. We have also exemplified how the FSSD makes it possible to prevent damages, even from yet unknown problems, and not the least, to guide selection, development and combination of supplementary methods, tools, and other forms of support, which makes it possible to increase their utility for strategic sustainable development. Finally, we have shown that the FSSD is useful for structuring transdisciplinary academic education and research.

The appropriateness of a single unifying definition of sustainability has been questioned by some scholars as discussed by, e.g., Missimer et al. (2015b). We believe that many of the arguments against such a definition are alleviated by the *principled* definition we propose, allowing for great freedom and diversity, and for values and preferences to be weighed against each other and in relation to scientific knowledge, when details of visions and transition routes are to be decided upon. There are many possible sustainable societies (all complying with basic sustainability principles) and there are many possible routes towards sustainability. When specific actions are to be chosen and combined in different contexts and scales, value-based opinions *should* be encouraged and *should* play an important role. A science- and logics-based framework of the presented type actually allows for true differences in values and preferences to become

clear and aids the dynamics of co-creation processes. Conversely, polarities based on misunderstandings and lack of knowledge is something we can do better without. Debates can become more elaborate and fruitful since time and efforts do not need to be wasted on visions that can be ruled out scientifically and therefore need not be debated. The benefit of a single unifying definition is multi-fold, the most obvious perhaps being that it aids coordination of competences across disciplines and collaboration across sectors. Each sector can identify their respective challenges, opportunities, and prioritized early steps in relation to the same sustainability principles, compare notes, and then find avenues for collaboration (as opposed to silo-mentality and compartmentalization). A further discussion on the appropriateness of a single definition of sustainability is given by Missimer et al. (2015b).

As a reflection, one may ask if the set of sustainability principles of the FSSD is the only possibility for a unifying operational definition of sustainability. Other possibilities cannot be excluded. It might be possible to identify other principles that closely fulfill the above criteria (necessary, sufficient, general, concrete and non-overlapping), which would somehow cut through the system in another way. So far, however, to our knowledge, the sustainability principles of the FSSD are the only ones that have been aimed at fulfilling these criteria and thus designed for the purpose of being useful for backcasting planning and redesign for sustainability. Other principles in the sustainability context, such as the Brundtland definition (World Commission on Environment and Development, 1987), the Cradle to Cradle principles (McDonough and Braungart, 2002), the Natural Capitalism principles (Hawken et al., 1999), and others, are further away from fulfilling the above mentioned criteria, likely because they have not been designed for backcasting planning and redesign for sustainability nor to be unifying, e.g., for analyzes, assessments and coordination of other frameworks, concepts, methods, tools, etc. As seen, the FSSD has been used extensively for the latter, and we expect that much more knowledge and competence will be developed on how the FSSD and other forms of support can be mutually supplemental. To re-emphasize, the purpose of the FSSD has never been to replace or exclude other forms of support for sustainable development, but the opposite; to provide a structure that allows for clarification of their respective strengths and that aids a coordinated use of them.

In conclusion, there is ample evidence that the FSSD works as intended, truly supporting strategic sustainable development for those using it. However, the many good examples of proactive leaders and change agents among academic institutions, businesses, municipalities and regions using the FSSD (or similar thinking) are still far too few in relation to the sustainability challenge. How could a more widespread use be achieved? This is a question we continually struggle with.

It is a bit of a dilemma. On the one hand we have the underlying driving question of the whole work; how can humanity hope to succeed with the complex task of transitioning to a sustainable society without having a unifying and operational definition of that goal, and a systematic approach to planning and acting for the fulfillment of it, implying that we believe a framework like the FSSD is necessary. On the other hand, such a framework is by necessity quite sophisticated. It takes some time to come to a level of mastery where the subtle understanding of the strategic approach it allows for and thus its full strength comes to the fore.

Learning the principles of checkmate is easy, but chess is much more, and becoming a skillful chess player takes significant effort. Similarly, learning the sustainability principles of the FSSD is quite easy, but the FSSD is much more, and becoming a skillful user takes significant effort. It might be felt easier to limit analyzes and actions to a fixed geographic area, to draw from certain predetermined fields of expertise, to consider a predefined set of known and 'popular' impacts, to turn to predefined sets of indicators, etc. Although many intuitively realize that this is insufficient and often counterproductive, the problem remains, it takes considerable time and effort to learn to master a more sophisticated and appropriate approach. Education and training is a key part of the solution, of course. Thankfully, much is happening on that front. Some examples have been mentioned in this paper and, positively, we also see a spurring interest from several business schools. Still, the question of how to get an ever wider use of the FSSD (or similar thinking) is pertinent. All ideas are welcomed.

Other ongoing development includes, e.g., further validation of the recently revised social sustainability principles of the FSSD (Missimer, 2015; Missimer et al., 2015a, 2015b), including their usability in product- and service innovation, further development of FSSD informed methods and tools for procurement and value chain management (Bratt, 2014) as well as FSSD supported business model development (Franca, 2013; Franca et al., in this issue), refinement of a new model for repeated FSSD use for multi-stakeholder collaboration (Borén et al., 2015; Robèrt et al., 2015), development of an FSSD informed framework for sustainable food system development, and an FSSD informed review of the macro-economic system. The latter has been spurred by the fact that proactive leaders using the FSSD want to progress faster than they can because of current obstacles. Consequently the main research questions of this upcoming study include: (i) what are the major current obstacles implied by the economic system and the way it is applied, which are perceived to prevent faster progress towards sustainability? (ii) which of the current obstacles can be handled without changing the economic system, and how (e.g. changing the norms by which the system is applied, rather than necessarily changing the system as such)? (iii) what modifications of the economic system would make it better support proactive leaders in making strategic step-wise transitions towards sustainability? (iv) what modifications of the economic system would better encourage late comers to also make decisions that support sustainable development (to significantly increase the pace of sustainable development at large)?

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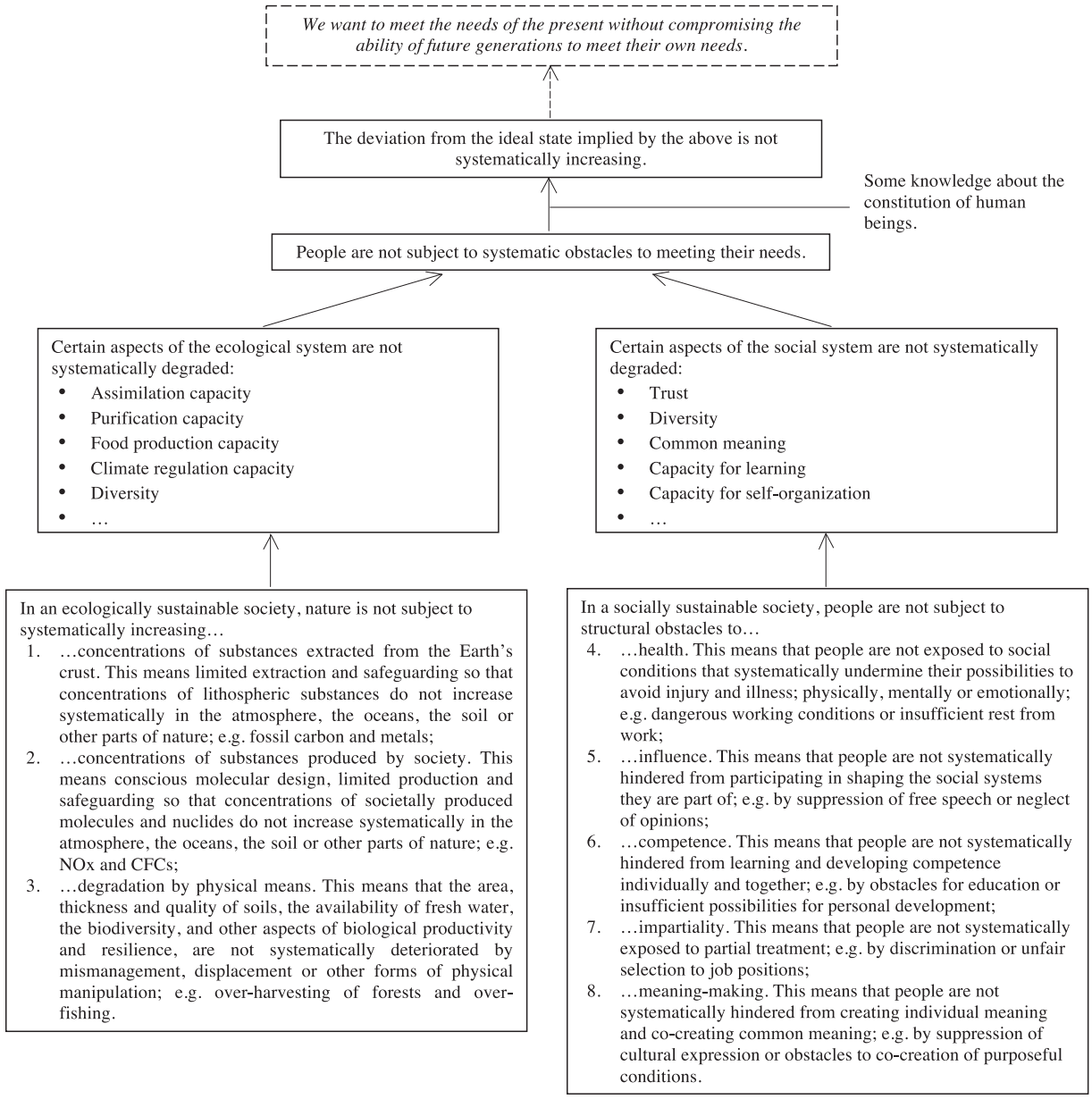
Appendix A

The chart shows relations between various entities related to a principled definition of sustainability. The arrows have the following meaning: *what is in the box at the tail of the arrow (if true/fulfilled) makes what is in the box at the head of the arrow possible/true/fulfilled.*



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