Social sustainability by design: Experiences with the Sustainable Awareness Framework *

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Abstract
Several techniques have been developed over the years for capturing sustainability requirements including capturing social and personal sustainability issues e.g. related to discuss ethics and values in connection to software solutions. One of these techniques is the Sustainability Awareness Framework (SusAF) which covers both environmental, social, individual, technical, and economic sustainability. We have used this technique in both industrial and academic settings, and in this paper, we will share some of the experiences with the technique and point to improvements. Better tool and method support is perceived useful to be able to have more detailed analysis of different aspects of sustainability and follow this up in software development over a longer period of time.

Keywords
Sustainability requirements, Sustainability awareness, Method evaluation

1. Introduction

Information and Communication Technology (ICT) plays an important role in assuring both social, environmental and economic sustainability. The need for the ICT field to address sustainability has been acknowledged for a long time in areas such as information systems [17], Human-Computer Interaction (HCI), and software engineering [3]. The impact of ICT can be seen as both direct and indirect effects of the software and hardware [8]. Direct effects such as energy consumption are what Hilty et al. [8] denote first-order effects. Second-order effects include the consequences of processes being changed by the application of ICT. Third-order effects are seen as long- and medium-term change in behavior, such as change in consumption patterns, and change in economic structures. The use of new technologies such as AI and IoT can be important for creating positive secondary effects to address sustainability challenges given we are able to use new technologies sufficiently rapid for potentially achieving positive effects [16], but can have even larger negative first-order, second-order and third-order effects if used wrongly. The information system and software development processes are the most important enablers for a future where ethical and trustworthy IT solutions impact the quality of people's lives. Today, the processes for designing and evaluating software are primarily based on direct functionality, cost and monetary value for industry, without sufficient focus on the

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wider societal and environmental impact. A shift towards a focus on sustainable development constitutes a major change in perspective. In software engineering and other sectors, there has been some focus on the environmental dimension of sustainability, evidenced by [2,7]. However, there is a growing need to investigate the social dimension, combined with the individual and human dimensions, to achieve sustainability in software engineering [4,6,11].

As seen in [2], there are several approaches to sustainability by design, looking at sustainability concerns already in the requirements phase. One of these, known as Sustainable Awareness Framework (SusAF) has been developed by Becker et al [4] and is structuring the effects of software systems into five dimensions. Three of them have been used in several sustainability models since the eighties: The economic (monetary), the environmental, and the social dimensions. To this, Becker and colleagues add the individual and the technical dimension. In a review study of techniques to take sustainability into account in requirements engineering, SusAF is the most discussed approach, but these are publications from the team who developed the framework, beyond what is described in this literature, the application of the framework is limited [2].

In section 2 we will present SusAF in detail. In section 3, we elaborate on the method including the usage of the method in different settings. In section 4 we discuss experiences from the use and point to both positive aspects and areas with room for improvement. Section 5 concludes the paper, pointing to further work.

2. Background on SusAF

The five dimensions of sustainability used in SusAF are often depicted as a pentagon as seen in Figure 1 below. For each of the five dimensions, the model distinguishes between immediate, enabling and structural effects, corresponding to the first-, second- and third-order effects described briefly above.

This pentagon model has been used in the development of a model for sustainability evaluation of ICT projects [4,13] where it is denoted as 'sustainability analysis diagram' (SusAD). Specifically, SusAF is composed of the SusAD, the chart for visualizing potential sustainability effects of a software system, and five question sets for guiding exploration of the five sustainability dimensions [13]. Other frameworks combine the personal and social levels into one, having four dimensions [11].

The model discussing this from a software engineering point of view.

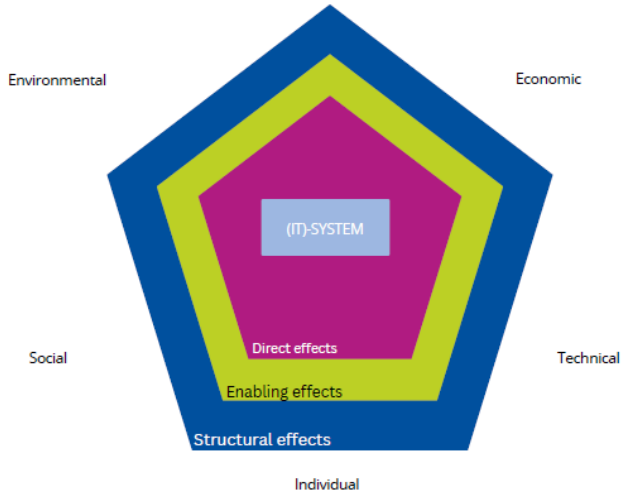

Figure 1: Sustainability analysis diagram (based on [4]).

The five dimensions can be described in more detail in the following way [4,13]:

- The environmental dimension covers the use and stewardship of natural resources. It includes material and resources, waste and pollution, biodiversity, energy and logistics.
- The technical dimension covers the ability to maintain and evolve artificial systems (such as software) over time, including aspects of maintainability, usability, adaptability, security, and scalability.
- The individual dimension covers health, lifelong learning, privacy, safety, and agency.
- The social dimension covers relationships between individuals and groups. This includes sense of community, trust, inclusiveness and diversity, equity, participation, and communication.
- The economic dimension covers financial value, customer relationship management, supply chain, governance and innovation.

Aspects within these dimensions are often interlinked, so that an effect in one area can have a positive or negative effect on another effect in the same or different dimension, on another level.

A standard technique has been developed for the usage of this framework to gather requirements for doing analysis of a setting in a facilitated manner. A workbook describes this process accommodated to different timings typically between 2 and 4 hours according to the process depicted in Figure 2.

An important part of the framework in addition to the pentagon diagram and the process, is a set of driving questions within each subarea of the dimensions as described above (privacy, safety, energy etc.).

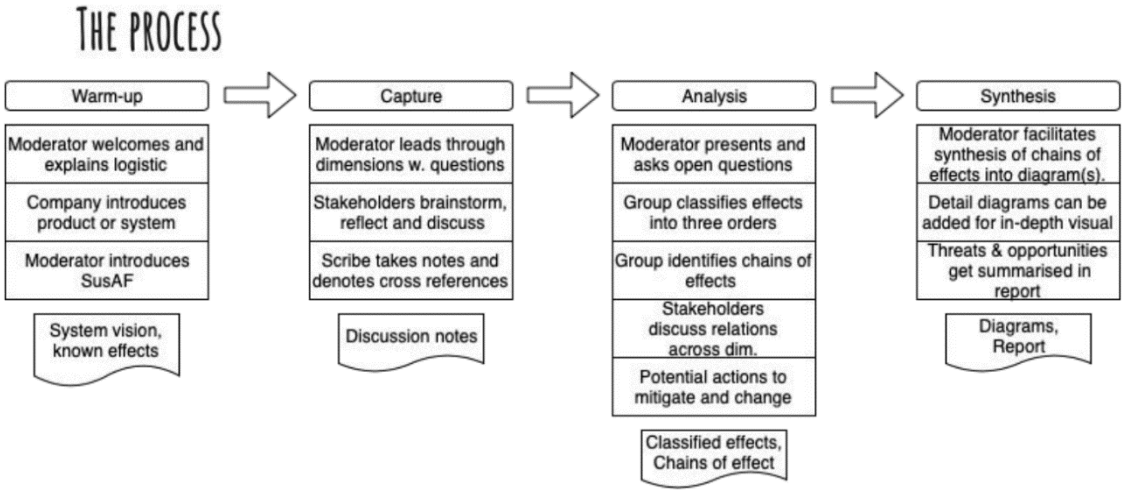

Figure 2: Standard SusAF workshop process from [13].

3. Selected experiences

We have used the SusAF framework in many settings, both within academia in connection with courses, in research and in industrial projects, and in workshops together with practitioners. The technique is meant to be generally useful, thus we find it interesting to bring together experiences from quite different usage settings.

The technique has typically been used in facilitated workshops, in some cases with a follow-up. The experience reported from here are from the following cases:

- Redesign of a mobile augmented reality system (MAR) [5].
- A 4-hour workshop at a practitioner conference on ICT in public sector.
- Used as part of an HCI- course on university-level.
- Used as part of a service design process used in a course on digital innovation.

3.1. Mobile Augmented Reality (MAR)-project

Description of setting: The aim of the project was to redesign a MAR application with a focus on sustainability design. The motivation for re-designing was the poor technical sustainability in third-party service and therefore, sustainability design was chosen as an integrated approach for redesign. A workshop was arranged. The objective of the workshop was to discuss the app's sustainability issues and envision the development of the app. Five participants who were involved in the previous version of the app joined the workshop. Participants were mostly developers, and one participant had a design background.

Detailed description of how the technique was used: Before the workshop, previous work in the field of MAR travel guide apps was searched to create a potential list of sustainability issues and topics that could be relevant discussion topics during the workshop. Then, a workshop was organized to envision the sustainability of the system within a decade and to capture chains of effects. During the workshop, two researchers together with participants, worked on a mapping exercise based on SusAF. For that purpose, information material about

the technique was sent to participants beforehand. The workshop started with a brief introduction to the project and the identified sustainability issues, followed by an introduction to SusAF. Roles were assigned, where the participants were responsible to discuss one dimension each of SusAF but could contribute to all. Then, participants were given three tasks: a mapping exercise, levels of effects and chain of effects. In all tasks, participants worked first individually and then in the group. In addition, driving questions were used to spark discussions, or redirect when it was needed. The workshop lasted approximately 2 hours and, at the end, facilitators concluded by summarizing findings and discussing experiences. Finally, sustainability issues with immediate effects were selected for further development into design suggestions for an MAR app.

Description of learning related to the use of technique: Overall, participants reported positive experience with SusAF. The stepwise process of the tool gave participants a systematic and integrated approach to work with sustainability design, with guidance through specific tasks to follow and a clear sequence of steps, ensuring that all relevant aspects and dimensions of sustainability are addressed. Especially for the extraction of design suggestions, it allowed formulation of requirements that were easily translated into design suggestions. Regarding the teamwork, SusAF allowed multidisciplinary view on sustainability and role-playing activity for participants.

There were also some challenges associated with the use of SusAF. First, there is a lack of collective understanding of what sustainability means for software development and how to identify sustainability issues. Identifying such issues and mapping them to dimensions is not an easy and straightforward task. It requires preparation, research and benchmarking existing MAR apps or similar technologies to identify common sustainability challenges and best practices. Furthermore, applying SusAF demands good understanding of the framework and its application, which may require specialized knowledge or training. Finally, translating sustainability issues into design suggestions is an iterative and ongoing process, where a deep understanding of sustainability issues, user needs, and the application context are needed.

3.2. Workshop at practitioner conference

Description of setting: Practitioners in public sector and IT industry who did not know each other in advance signed up to one of ten parallel workshops at a conference. They worked physically with different colored post-its on a pentagon-poster, and with a flip-over to support the prioritization of ideas. The participants worked on a partly artificial case (i.e., the case was real but was not from the participants themselves).

Detailed description of how the technique was used: The workshop lasted four hours. An one hour introduction to sustainability issues and SusAF was followed by a three-hour workshop, including a 30-minute break and a 30 minute wrap-up. The workshop followed the prescribed process: The case was introduced. Each participant devised 2-3 impacts per dimension individually, with different colors for positive and negative effects. Then all points were discussed and prioritized by the whole group. Points that were regarded as high priority were put on the A1 SusAF board as illustrated in Figure 3. Then the different effects were connected wherever relations were identified. Two facilitators helped.

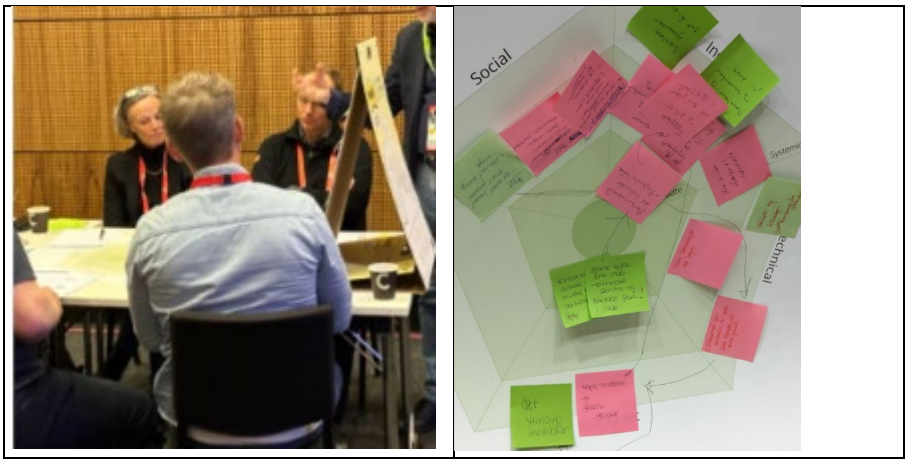

Figure 3: Pictures from the practitioner workshop.

Description of learning related to the use of technique: Not knowing each other at the outset, it took some time for the participants to become comfortable. In such setting it is often useful to work on a situation not being from one of the organizations. It was an advantage to do the prioritization i.e. not put everything on the pentagon from the start. Still the middle of the chart became cluttered, and it was hard to model the relationships on the board. That the pentagon looks like a spider diagram also made some participants a bit confused in the beginning. Participants gave positive feedback on the usefulness of the technique but did not feel comfortable about running such workshops themselves.

3.3. Workshop with students as part of a course

Description of setting: The setting was a mandatory 7.5 ECTS course on CSCW and user-centered design for 1st year students in a business-oriented IT bachelor program. The course included a set of assignments together comprising a small design project where groups of 4-5 students worked on a solution to be implemented in Sharepoint.

The overall objective from an educational perspective was to enrich the course with learning activities that would contribute to achievement of the existing learning outcomes. Including a SusAF analysis in the projects was to help the students become more aware of sustainability effects of their proposed solutions and acquire skills in identifying sustainability effects in other settings.

Detailed description of how the technique was used: At the time of using SusAF, the students had started work on personas and scenarios for their design projects. A half-day facilitated SusAF workshop was provided within normal lecture time in the course. Attendance was strongly encouraged, results from the workshop being part of an assignment to be handed in, and close to everyone (ca. 40 students) in class attended. In the workshop, an introduction to the framework was given by the instructor, including examples referring to their case. Next, the students worked in teams to develop SusAD diagrams for their own solutions. Key adaptations of the process include:

- Students were working in a co-located manner in one large room.
- For the diagram, A1 cardboard templates, post-it notes and pens were used.
- The five sets of driving questions were distributed to all groups to help them identify sustainability effects.

- Instructions were given that the groups might choose two or three main types of functionality/features of their design and make one diagram for each.
- Presentation of the results in were made in clusters of groups (3 groups presenting to each other).
- Evaluation of the use of SusAF was covered indirectly as workshop results were part of an assignment and as students reflected on the course activities as part of the summative evaluation (pass/fail) in the course.

Description of learning related to the use of technique: The task and technique were easy to understand for the students. Only limited facilitation of the groupwork was needed. Having a similar (although not identical) case among the participating groups made it possible for the instructor to create examples that all participants could easily relate to, making the introduction to the technique efficient and effective. The sustainability analysis was considered meaningful considering the overall learning outcomes and activities in the course. The intervention demonstrated that it is possible to enrich a curriculum with insights on sustainability by use of SusAF without necessarily making resource-consuming changes to a course and without creating the feeling of sustainability focus being enforced top-down and/or in a superficial way. The students reported getting new insights/ideas from other groups presenting their diagrams. Focusing on distinct aspects/functionalities/features in separate diagrams helped avoid cluttering of the diagrams (but at the known expense of not being able to make connections between sustainability effects across the diagrams).

3.4. Used in service design in a multidisciplinary course on digital innovation.

Description of setting: SusAF was used in connection to a service design process following a double diamond approach [10]. It was used two times, first on the problem statement, and then on the final prototype solution to see if it had to be updated when the group knew more about the technical solution. The process was part of a cross-disciplinary course for bachelor students where together they were meant to provide input to a digital innovation using XR-technology.
Detailed description of how the technique was used: The workshop was held in 2 hours (which is less than normal). The week before, sustainability and selected techniques such as SusAF had been presented. After a short introduction to the framework, the students worked in their established cross disciplinary groups for two hours. The physical setting was using different colored Post-its on an A1 poster showing the pentagon. The students worked with one idea at the time, and each student focused on one dimension. Invariably and archetypically, in each group it was the IT-student who was put to work on the technical dimension. Based on the driving question each participant came up with issues and presented them to the others (one at a time). After a lunch break, the students discussed how issues were related, and identified issues to have in mind in the further work. The groups then presented their findings to the other groups.

The second part was to take up the first analysis and see to what extent it was changed based on new knowledge achieved, while developing and evaluating a prototype, and report changes in the sustainability analysis in the final project report 2 months after.
Description of learning related to the use of technique: The students were quickly able to start using the techniques on their initial ideas. They had discussed their ideas up front and were at the time quite familiar with each other. Having a lecture on the technique before using

it was also useful. We witnessed at least one group learning during the project as demonstrated by the final prototype including aspects not in the original idea. These were social and individual aspects. A tool for documenting the results in a more persistent way would have been useful, according to the participants. In the case, the results were documented by taking pictures of the board.

4. Learnings and suggestion for improvements

In general, those who work with SusAF for the first time find it possible to use the technique after a relatively short introduction on sustainability and the framework. Many are positively surprised, especially to find that it not only about environmental sustainability, but also covers the social and individual aspects. It is important, though, that the first usage is facilitated. Below is a summary of possible improvements.

The workshop-version of SusAF available on the web [13] provides one workshop setting/timing. In practice (and due to different constraints) we find it useful to use different variants of this, based on e.g., how well people know each other before the workshop, importance of results, and what is the main objectives (develop software requirements, learning about sustainability…).

Participants tend to be satisfied with the outcome of a SusAF workshop, having collaboratively identified relevant sustainability effects and seen connections between them. However, to get the most out of the analysis in the longer term, we see a need for guidelines for the long-term usage of the results. There is existing research on e.g., how to bring SusAF into agile development, but this must be further experimented with [1]. Another approach is to set aside time after the workshop to further analyze the situation, and then return to another session of updating the model, as we did in the service design case and in the MAR-case and using the result from the last workshop for developing quantifiable requirements.

As found in the MAR-project, it is often necessary with preparatory work before the workshop, both for facilitators to understand the domain, and for the participants to quickly start using the approach when at the workshop.

The technique is primarily manual to be used in a physical workshop setting. This can provide a good process to brainstorm and come up with initial ideas. When many ideas come up it is however not easy to work with the diagram, and to bring forward the results e.g., to design activities. Better tool support is needed, for the immediate analysis, for bringing the result further, and for adding more detail, including assumptions for the issues raised. This tool support should be linked to a proper modelling method. In the literature, e.g. SAF [11] provides a modeling method and tool to support it. A SusAF Miro-canvas exists, but it is not very advanced considering the modeling one typically does in requirements engineering and design. Another advantage of better tool support is that it will make it easier to discuss the quality of the results produced, e.g. by adapting general frameworks for evaluating the quality of models [9].

The pentagon-shape itself has some challenges. In our cases we have seen that it gave some participants the erroneous impression that it is a spider-diagram. Another challenge of the diagram layout is that most of the ideas are on the immediate level, which offers the

most limited space. This quickly leads to cluttering even when concerns are prioritized before being put into the board. This problem might be addressed by simply changing the proportions in the diagram, and with better tool support. A general concern regarding the use of digital tools is that their use should not get in the way of the modeling process of the humans [15]. A key affordance of the pentagon diagram is that it facilitates low-threshold collaboration between stakeholders who do not need to possess advanced knowledge of digital tools. Appropriate modelling tools should maintain this advantage. There are also some challenges with the proposed list of topics for each dimension. Some of them, such as privacy often being a subset of security, go across several dimensions, which can be confusing. On the other hand, since the topics are only proposed to drive the process and help the participants not to forget areas, this is not so problematic. A bigger challenge is what we regard as wrong placement of topics e.g. topics linked to dimensions where they arguably do not belong. For instance, in our view usability is primarily a means to improve the personal dimension, not the technical one. There are also missing areas, e.g., universal design as a concern on the individual level. On this basis, we see that the topic lists could be updated. It should be noted at this point that the authors of the SusAF framework do not claim that their proposed topic list is exhaustive.

It is challenging at times to decide the level of a sustainability effect, and more support for the appropriate selection of level should be provided. In [14] a fourth level is suggested, which might make it easier to be clear on the level to use. At the same time a fourth level introduces a risk of making the technique more complex.

5. Conclusion and further work

The SusAF framework has been used in several projects and project settings. Many pilots of the use of the technique have been conducted by us and others. There is now a need for studies that address the use of the technique in more detail and considers the process over longer time, e.g., how to support the development and evolution of (IT)-systems. In an educational context, learning outcomes (e.g. related to discipline knowledge or sustainability knowledge) should be evaluated after a certain time period. Also, one should look at support for doing more systematic evaluation using e.g., MAM – Method Acceptance Model [12]. We should also evaluate the quality of the result. The resulting SusAD is a model that one can evaluate using e.g., SEQUAL [9].

This paper provides early results on the experiences of use of SusAF, collected in an informal way. In later project and usage situation, we aim to follow the use more systematically, to have even better grounding for our proposals to update the technique.

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