



# Social Sustainability Approaches for a Sustainable Software Product

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## ABSTRACT

Sustainability is the use of existing resources without compromising them for future generations. Resources must be guaranteed in the environmental, economic, and social dimensions. Sustainable Software Engineering is an emerging research field aiming to minimize software development's negative impacts on society. Furthermore, software sustainability can be defined as a way of keeping something running at a certain level of quality in relation to these dimensions. From the social dimension perspective, it is necessary to confirm software's trade-offs, benefits, and impacts on society since it lacks empirical evidence of its achievements in software. In this research thesis, we will explore how the literature addresses the aspect of social sustainability during software development and understand how social sustainability approaches can be integrated into the context of agile software development. In the end, we expect to have a set of guidelines, activities, and practices that can be adopted by agile teams.

## Categories and Subject Descriptors

K.6.3 [Management of Computing and Information System]: Software Management—*software process*; H.1.2 [Information Systems]: User/Machine Systems—*human factors*; D.2.1 [Software Engineering]: General—*standards*;

## General Terms

Algorithms, Management, Measurement, Documentation, Performance, Design, Experimentation, Security, Human Factors, and Theory.

## Keywords

Sustainable software engineering, agile software development, social sustainability, human values, empirical practices, social aspects

## 1. INTRODUCTION

Sustainability is the use of existing resources without compromising them for future generations [3]. In software engineering, the definitions that relate sustainability and software complement each other in the sense of predicting when sustainability is achieved. In 2014, Penzenstadler et al. [25] described software sustainability in two definitions: 1) the software code being sustainable, regardless of purpose, or 2) the software's purpose being to support sustainability goals.

Recently, Calero et al. [5] define Software Sustainability as "the capability of software to last a long time by using only the resources that are strictly needed." In addition, they also discuss the term "Software as part of sustainability," which "considers software as a new dimension of sustainability, including the interaction of the software with the other dimensions of sustainabil-

ity." They further discuss "Sustainability IN Software" and "Sustainability BY Software." "Sustainability IN Software" is defined as adding sustainability concerns during software development. "Sustainability BY Software" is "a tool used to achieve sustainability within any context." All those definitions are followed by dimensions which depending on the author's interpretation, can be divided from 3 to 7 dimensions [28]. Generally speaking, they are a) Economic; b) Environmental; c) Technical; d) Individual; e) Human; f) Political, and g) Social.

Since 2008 the focus of sustainability in IT has been dedicated to environmental aspects and mainly covering energy efficiency, energy performance, cloud, and data center energy consumption practices [4] [7] [22]. So far, studies of economic aspects have dealt with the indirect impact of the socio-environmental practices adopted and, most of the time, with the organizational benefits of applying sustainability initiatives in companies [10]. The economic aspect is a consequence of using socio-environmental practices during software development [16]. Indeed, some studies introduce social concerns to think about during software requirements [11] [6]. However, there is still room to investigate the contribution of integrating social sustainability in an agile context and other phases of the software development life cycle.

An example of why it is important to address social issues is the case of social media, which was primarily created to connect people across the world. The intention was to enable a participatory society and consequently contribute to social sustainability. However, it is possible to perceive the negative impacts of social media related to: a) increase in mental illnesses [1]; b) manipulation of democracy [2]; c) accounts being disabled and people losing their data without having access to transparent social media content rules [19]; d) and violation of personal data [24]. In this case, the negative impacts of social and human issues could have been addressed in the conceptual phase of a software product. Adding social sustainability approaches into Agile Software Development (ASD) might be a way of avoiding these negative impacts, especially when dealing with user-centered activities.

The social and human issues mentioned are related to the values presented in the Winkler [28] study. The connection between social sustainability and human values is determined by a top-level that contains and can be defined through the middle-level elements expressed as human values. He even listed 31 human values from the literature, regulators, and government and divided them into three main areas: a) design and engineering; b) sustainable development, law, and human rights; and c) psychology, philosophy, and ethics. In this study, he proposed an extended list of values with overarching values and specific aspects. Some are about justice, dignity, equality, freedom, security, community, trust, usability, transparency, human well-being, ownership, pri-

vacy, and so on.

The dynamics of Agile Software Development (ASD) open an opportunity to explore social sustainability approaches. From designing a software product to its delivery. ASD allows for user participation, constant feedback, and continuous improvements [15]. The combination of these approaches and a set of human values during software development can contribute to the social sustainability of software. Therefore, an agile context is appropriate to minimize and/or anticipate the negative impacts of software on social sustainability.

Furthermore, agile software development organizations may unconsciously exercise one or more social sustainability approaches when developing their software products [16]. Agile organizations often try to create unconventional work environments, giving space for creation, understanding of user problems, exploration, and exploitation of new ideas to develop innovative solutions for society [18]. One of the first steps to address software product social sustainability issues is to embrace social sustainability throughout the software development lifecycle.

From this point of view, the contribution of this research will be to identify how social sustainability can be approached in an environment of continuous software development.

The rest of this paper is organized as follows: Section 2 discusses social sustainability in software. Section 3 shows the proposed research detailing how the investigation will be conducted, the social sustainability framework, and the threats to validity. Section 4 describes the progress to date of this early-stage research. Finally, to conclude this paper, we report the study expected contributions in section 5.

## 2. SOCIAL SUSTAINABILITY

Aiming to differentiate each dimension, [20] defines Social sustainability as "focuses on ensuring current and future generations have the same or greater access to social resources by pursuing generational equity. For software-intensive systems, it encompasses the direct support of social communities in any domain, as well as activities or processes that indirectly create benefits for social communities." In this case, the social dimension is related to the impact of software on society. For instance, a software could promote inclusion or exclusion. In contrast, a software could promote social justice and a sense of belonging as well. [6] proposed a model about sustainability quality requirements addressing some of these social issues in the social dimension. The survey participants identified some of the human values as a priority: trust, security, usability and freedom.

The study of Khalifeh et al. [16] proposes a framework to incorporate sustainability into software projects, but before proposing the framework, an extensive review of sustainable software is performed, confirming that many studies in software engineering cover environmental aspects of sustainability [16]. The author emphasizes the need for relating the triple bottom line (TBL) of sustainability aspects such as economic, environmental, and social because they aim to achieve any asset without harming the next generations by ending the resources available today [12]. There is a concern from the author about the social aspect, which in most studies was not mentioned, or the studies covered only environmental and sometimes economic aspects. In this case, the proposed framework relates the software quality standards and PQM of ISO/IEC 25010 to social aspects of sustainability [13].

Most recently, Swacha [27] conducted a scoping review on models of sustainable software with 42 papers. Of the selected papers, most focused on the energy efficiency of sustainability and few focused on the holistic approach to sustainability - some of them covered all the dimensions or added more dimensions, such as human and technical, to sustainability. There were no papers covering only the social sustainability aspect.

Li et al. [21] provided in their mapping study some insights about the relationship between architecture erosion and a non-sustainable software product in terms of software requirements, software quality, teams, and organizational communication. Although architecture erosion can be related to software sustainability, it was not possible to identify the direct approaches to social sustainability.

The Sustainability Awareness Framework [11] and the Software Sustainability Model [6] are the closest tools to consider social sustainability during software conception and software development.

## 3. PROPOSED RESEARCH

This section presents the initial research methodology, proposal, and evaluation of the Social Sustainability Framework. The threats to validity are sketched out as well.

### 3.1 Methodology

To understand how social sustainability approaches can be integrated into continuous software development, this research is planned based on Design Science Research (DSR). The goal is to use this methodology to help create a design artifact or theory that is effective for the diagnosed problem in organizations [14].

Ultimately, the solution designed based on the aspect of Social Sustainability and human values will guide the software developers on how to minimize the negative impacts of the software product on social sustainability. Combined research methods will help collect and analyze the data for this study, as presented in Figure 1.

We started from the Systematic Literature Review (SLR) [17] to identify studies that address the aspect of social sustainability and human values in software engineering. The SLR will answer our first research question, "what are the existing social sustainability evidence and support tools from the literature?" and the outcome of this stage will be the research definition.

The second part is the multiple Case Study [29], which will be performed in Norwegian software companies committed to sustainability standards and regulations to understand the current phenomena [26] [23]. This exploratory research will answer the second question about the approaches that might be applied in Norwegian companies systematically or not.

Canonical Action Research [9] will be conducted to identify how the approaches can be integrated into agile companies. Therefore, the third research question will be answered by understanding how the approaches from the literature can be integrated into agile teams.

The fourth research question aims to identify the challenges and benefits of integrating these approaches. The outcome will be the framework evaluation from the company's point of view.

#### 3.1.1 Step 1 - Systematic Literature Review

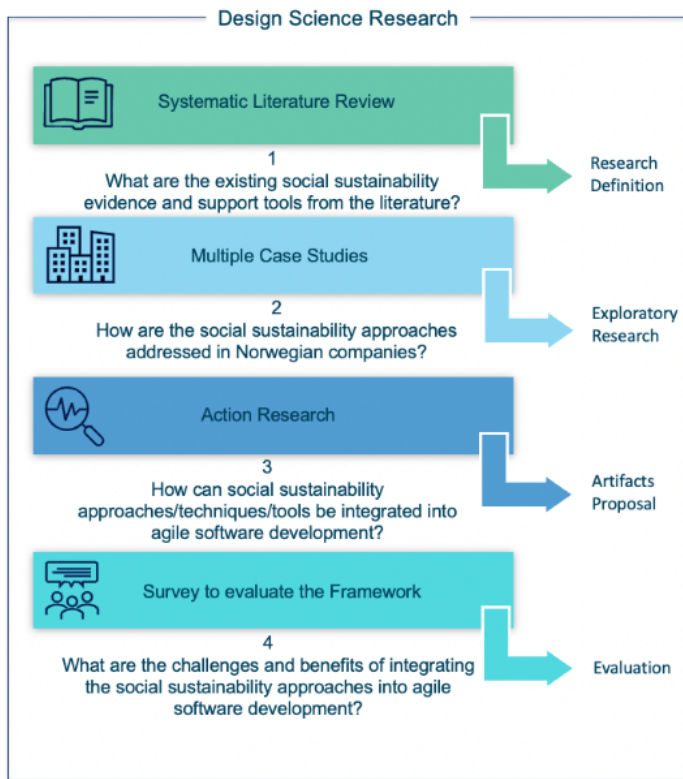


Figure 1: Research Methodology Sketch

The first part of this research is to conduct a Systematic Literature Review (SLR) to understand and explore the research topic [17]. The SLR aims to investigate the existing literature regarding the sustainability dimensions of sustainable software. We are searching for papers that cover all the sustainability dimensions in software development and also mobile development. Based on the goal, we have defined the following SLR research questions:

- RQ1 - What are the existing studies investigating the social aspects of sustainability in software products?
- RQ2 - How are the studies evaluating the social sustainability aspect of a software product?
- RQ3 - What is the evidence of sustainable software engineering approaches to social sustainability?
- RQ4 - What are the factors and actors that contribute to developing a sustainable software product?

After executing the exclusion and inclusion criteria, based on the research questions, we are selecting the studies that have reported social sustainability approaches in their studies and moving on to the data extraction phase. The construction of data extraction is still in progress. So far, we have some preliminary information we want to extract from the secondary studies in Table 1 for sustainable software products and sustainable software engineering.

Regarding the data synthesis, the thematic analysis will synthesize the data obtained and combine the findings [8]. The SLR results will allow us to move forward with the research definition. This result will shape our exploratory research in Norwegian Companies throughout the case study and action research in agile teams.

Table 1: Data Extraction Template

RQ1 - What are the existing studies investigating the social aspects of sustainability in software products?

- 1 - Bibliographic Reference
- 2 - Study type
- 3 - Aims of the study
- 4 - Type of software product
- 5 - Software Life Cycle phase addressed
- 6 - Sustainability Dimension
- 7 - Social Aspects
- 8 - Business Domain of the application in which the study was conducted

RQ2 - How are the studies evaluating the social sustainability dimensions of a software product?

- 9 - Quality attributes of sustainability to evaluate the sustainable software product quality
- 10 - Sustainability assessment approach

RQ3 - What is the evidence of sustainable software engineering approaches on social sustainability?

- 11 - Metrics to assess the social sustainability of the approach
- 12 - Support tools used to measure, monitor, or enable the sustainability of software product

RQ4 - What are the factors and actors that contribute to developing a sustainable software product?

- 13 - Actors (stakeholders, end-users, agile teams, society)
- 14 - Positive and negative factors

We expect, by the end of SLR, to have a set of tools that can be integrated into agile teams. So far, we have found some frameworks that can be reused in the context of software development and some other activities that can be combined into these frameworks as complementary guidance to adopt sustainability practices into software development. Most of these frameworks address all sustainability dimensions. In our case, only the social sustainability dimension approaches are related to this study.

### 3.1.2 Step 2 - Multiple Case Studies

In order to identify how Norwegian companies are approaching social sustainability during software, multiple case studies will be conducted [29]. First, the unit of analysis is software development companies. Preferably the ones who run agile software development methods. The second is meeting and reporting on sustainability goals and achievements for any dimension of sustainability. Companies must be committed, open and have basic knowledge of sustainability. Identifying whether the company has internal sustainability training for employees is necessary.

This exploratory research will provide subsidies for the next phase. These inputs may confirm social approaches already in use in the companies involved in the case study or evidence of the need for social approaches. We will define the research protocol, interview script, schedule, contacts and research procedure.

### 3.1.3 Step 3 - Canonical Action Research - Artifacts Proposal

We want to investigate how social sustainability approaches can be integrated during continuous software development; for this reason, canonical action research is appropriated to be used as a method to guide our research [9].

In an Action Research environment, the proposal and evaluation are interactive, which means that as soon as we propose the framework, we will evaluate them within agile teams. The review will allow us to confirm the practical application of the social sustainability approaches. Rounds of feedback will be gathered to improve the framework.

The outcome of this third part is to create an empirical framework of how agile teams can apply social sustainability during agile software development to create a sustainable software product.

### 3.1.4 Step 4 - Evaluation of the Social Sustainability Framework

Finally, the fourth stage will be the evaluation of the Social Sustainability Framework in the agile context, which means we will measure the efficiency of the adopted practices, activities, processes, or guidelines to develop a software product.

## 3.2 Threats to validity

The threats to the validity of this research can be based on each method of the research methodology because each has its limitation and contribution. While progressing in the study, more constraints will be identified.

The Systematic Literature Review is a procedural research method that demands the work of one or more than one researcher to reduce the bias and confirm the finding as well as the conduction of this method. To mitigate internal validity, we plan to conduct the SLR with the supervisor in a weekly follow-up meeting. We are planning to have one more researcher outside of our university that is more experienced in software sustainability.

External validity might be noticed when collecting data from the participants because there is no control over their answers. We will create an interview script based on our research propositions and questions to avoid this threat.

Conclusion validity might arise whether one of the constraints, external or internal validity, occurs. It means that the creation and evaluation of the Social Sustainability Framework would not be possible. To avoid this, a list of organizations engaged in sustainability actions will be defined to identify the best ones that can contribute to this study.

## 4. PROGRESS TO DATE

Figure 2 illustrates the research timeline and the milestones of each stage distributed over four years of doctoral duration. Until the date of this paper submission, we have been working on the SLR which will allow us to define and refine the gap around the social sustainability approaches proposed or applied during the agile software development.

From Autumn 23 to Spring 24, the goal will be to diagnose the problem, define an action plan, make an intervention, collect feedback and improve it again in Norwegian Organizations. We expect to have preliminary results so we can present this in a midterm presentation and a publication of the preliminary results.

The Social Sustainability Framework will be evaluated on Autumn 24 and will continue to be assessed while Studying Abroad in organizations from different countries.

Finally, in Autumn 25, the final evaluated framework version will be considered and reported in a publication to be used by any

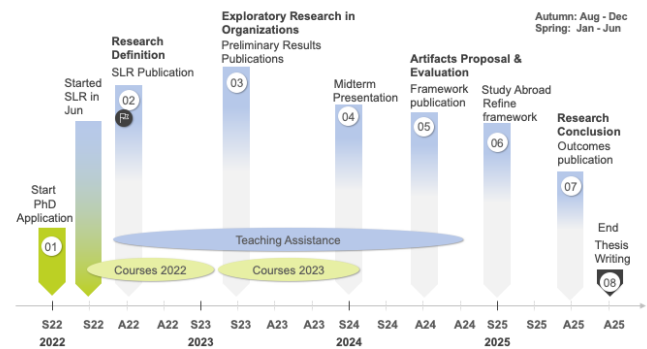


Figure 2: Research Timeline and Milestones

other organization. We expect to have activities, guidelines, or artifacts that can help the organizations to address social sustainability aspects during the software development. In this timeline is also possible to check other activities related to the Doctoral such as courses, teaching assistance, study abroad, and thesis writing.

## 5. EXPECTED CONTRIBUTIONS

As this is an embryonic study, some contributions can be highlighted. One is the opportunity to understand more about sustainable software engineering in terms of what beyond known software engineering best practices can be applied during software development to achieve social sustainability.

Social Sustainability is one of the aspects of sustainability related to the individual's participation in society demonstrated by the human values that characterize the present and shape the future of society. Thinking about sustainability means reflecting on whether the actions we take today can impact the future of the next generations, working to make this negative impact as small as possible [3].

These impacts can be reduced or mitigated when reflecting on what makes a software product unsustainable. Likewise, we can identify which approaches are important to follow or not to create socially sustainable software. The multiple case study and the action research methods will allow us to obtain these answers. The answers to these questions will be the second contribution of the research.

Regarding the third contribution, this study will provide the community with a practical framework of what, how, and when social sustainability approaches can be applied during software development. Furthermore, the artifacts created will allow companies and software developers to measure the scope of social sustainability. In this case, society's participation in actual software development can illuminate requirements decisions, sustainable software product goals, and the software sustainability index. This participation can be established based on user acceptance tests regarding social sustainability approaches. From the user's perceived effectiveness of the social sustainability framework, this study will report the difficulties and barriers to detecting, addressing, and applying social aspects in agile software development.

The novelty of this study is the creation of a social sustainability framework that will try to establish activities, actions, or guidelines that can be integrated into current agile software develop-

ment without overloading teams. The framework evaluation will provide constructive feedback on usefulness, clarity, ease of use, and behavior intention from the stakeholders in the agile context.

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