Integrating Sustainability Assessments into Software Management Practices

An Action Research Study on Optimising a Framework for Evaluating and Improving Software Sustainability

Master's thesis in Computer science and engineering

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Gothenburg, Sweden 2024

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Abstract

This thesis investigates the integration of sustainability assessments into software management practices, focusing on Husqvarna Group's initiative to incorporate sustainability scores into its extensive application portfolio. The research adopts an action research methodology to develop and refine a sustainability assessment tool that evaluates software applications across environmental, social, governance, and process sustainability dimensions.
The study identifies key criteria for defining sustainable IT and develops a framework that allows for the comparison of different software systems based on their sustainability contributions. By incorporating feedback from industry practices, company goals, and sustainability frameworks, the tool aims to facilitate more informed decision-making within enterprise IT strategies.
Key findings highlight the challenges and benefits of integrating sustainability into software management. The research underscores the importance of customizable tools that align with company-specific sustainability goals and regulatory requirements, such as the upcoming Corporate Sustainability Reporting Directive (CSRD). Additionally, it addresses the need for improved sustainability data, transparency in vendor practices, and enhanced sustainability knowledge among service managers.

Keywords: Computer, science, computer science, engineering, project, thesis, sustainability, ESG, CSRD.

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Introduction

When developing and evaluating software products, the focus throughout history has been on technical performance and cost-effectiveness, and more recently security and safety [26]. Developers and customers want their products to be efficient, secure, and cost-effective, and with good reason: a well-working program can lead to direct value for everyone involved. In reality, however, the effects of software stretch beyond the value it creates for a company and its customers [34]. They can have far-reaching social, economic, and environmental effects on society which have, historically, been overlooked, especially within the software engineering sector [7]. Raising awareness about these effects, both negative and positive, can make a difference in the future development and use of software products [28].

In recent years, this outlook on software has started to change [34][11]. With a growing market for sustainable software products and companies, in combination with a more conscious society, the value that a software solution provides has become a more nuanced discussion. Sustainability is starting to become a more important aspect of software design, and the industry is taking notice [4]. Researchers are also in the accelerating process of finding how sustainability should be incorporated into business practices and decision-making [25].

Figure 1.1: The UN's 17 Sustainability Goals[1]

There also seems to exist a difference in opinion regarding what sustainability entails. A significant portion of research and actions regarding sustainable software looked at in this paper focuses on environmental sustainability. However, when looking at the UN's 17 sustainable development goals (SDGs) laid out in 2015 as seen in Figure 1.1, only seven of them are directly aimed at environmental issues. The other ten include topics such as inclusiveness, diversity, equality, economic growth, peace, and health. With a rapidly growing IT sector, a greater responsibility to contribute to sustainable development is placed on its shoulders, and could ideally even be incorporated into early-stage software development [30].

1.1 Problem description

Mapping out and evaluating the effects that software can have has been a topic of discussion since the idea of more sustainable software development started taking root and has come with several problems. Without an industry standard, it is mostly based on internal factors and the sustainability goals of individual companies as compared to others. Even the more accepted sustainability evaluations such as ESG[2] scores do not have a standard as to how they should be applied to specific products and are instead based on company missions and reporting [8]. For these reasons, it can be hard for companies to evaluate their applications in a meaningful way that allows them to find areas of improvement. It can also be difficult to know when an application is simply not contributing to a company's sustainability goals

[1] https://www.un.org/sustainabledevelopment
[2] Environmental, social, and governance progress. Explained further in Section 2.1.1

and should possibly be phased out.

Incorporating sustainable design principles into software engineering processes has proven to pose significant challenges [7]. Research reveals that software practitioners often have a limited understanding of sustainability concepts, organizations exhibit restricted awareness of the potential benefits, and existing professional norms do not inherently support sustainable outcomes. An industry report also shows that a majority of company actions within sustainability fall short of the company's ambitions [4]. Addressing these barriers requires targeted efforts in sustainability education and a reevaluation of prevailing professional norms to foster a culture that prioritizes sustainable software development practices.

1.2 Purpose and aim of the thesis

This thesis aims to investigate sustainable IT practices through an action research study of Husqvarna Group's initiative to integrate sustainability scores into its application portfolio, ultimately contributing to improved enterprise IT strategies. By looking at common practices in the industry, company goals, and possible evaluation techniques, the goal is to introduce a way to evaluate an expansive portfolio of applications in a way that allows for comparison between individual applications and the extent of their contribution to sustainability goals.

The goal of the case company is to add a new value to their applications that can be used for comparisons to improve their decision-making when it comes to their current and future portfolio management. For example, they may have two programs that have similar performance and importance to the company and want to phase one out. If they could instead be compared by sustainability scores, the choice would not only be easier but could actively be beneficial to not only the company's goals but even the rest of society. It can also be used to find improvements in essential software that does not have any possibility for replacement. Through the identification of application shortcomings, this research endeavors to pave the way for enhanced sustainability practices, thereby yielding benefits not only to the company but also to broader societal and environmental concerns.

1.2.1 Case Description

The company on which the case study will be done is Husqvarna Group. Founded in 1689, it is one of the oldest continuously running companies in the world. Throughout history, the company has reinvented itself and its products, starting as a weapon producer in its conception and later as a sewing machine producer in 1872 and later transitioning into the forestry and gardening industry which is what it is most known for today.

Husqvarna Group boasts a vast catalog of over 1000 applications spanning robotics and IT tools, utilized across various departments for day-to-day operations and product management. In its current state, the application master contains several data attributes such as lifecycle, functionality overlap, and out-of-support infrastructure.

To improve upon this, they also want to add a sustainability attribute to make more nuanced decisions when planning and fulfilling enterprise and IT strategies. Today, they recently added a tool that supports this feature, developed by Orbus as part of their application manager, but its effectiveness, use cases, and areas of improvement are yet to be fully explored. The project will also collaborate directly with Orbus and relay feedback to them in hopes of improving the tool.

1.2.2 Case Tools

The tool currently in consideration for implementation at Husqvarna is an IT system portfolio management extension with a sustainability score addition and is based on a mix of sustainability frameworks. The extension allows system owners to evaluate and score different IT systems based on a set of questions within different sustainability dimensions. The dimensions used are based on ESG frameworks, meaning that they are separated into the categories: environmental, social, governance, and an added dimension for process sustainability. The last category focuses on the lifespan of a product and considers the sourcing company, decommission plans, and the functional scope of the product. This dimension was identified as a key category for companies that wanted to improve business processes surrounding a software solution.

The tool's scoring feature uses a set of Likert questions on a scale of 1 to 5 to create a mean sustainability score for a certain application. The questions and criteria for scoring will be established through this project to later be implemented into the tool. The list view showing applications and their different scores, business fit, technical fit, and sustainability score, can be seen as screen captures, courtesy of Orbus, in Figure 1.2 and the view of the assessment can be seen in Figure 1.3.

Figure 1.2: List view of application values

1.3 Research Questions

As previously mentioned, the thesis aims to improve and evaluate a sustainability scoring system for company applications to improve enterprise IT strategies within

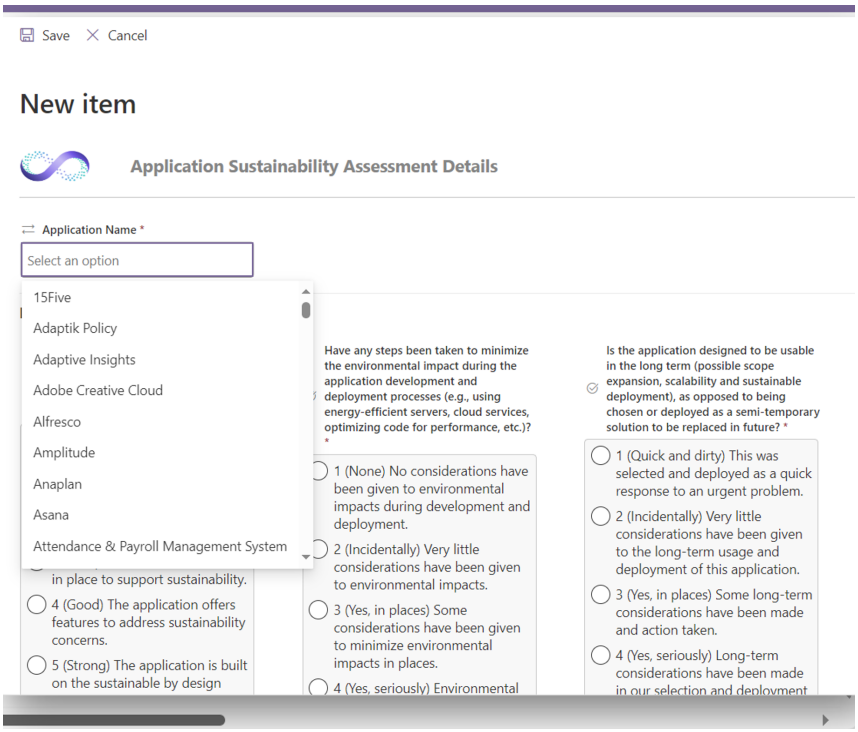


Figure 1.3: View of assessment

the company. As a relatively unexplored area of software engineering, this includes looking at current practices regarding this topic, as well as detecting areas of improvement. Given the evolving nature of sustainable IT, this thesis will examine the concept, acknowledging its absence of a standardized definition, particularly within business operations. The following research questions will touch upon these areas and fulfill the aim of the paper:

RQ1 What criteria can be established to define sustainable IT and data, facilitating meaningful comparisons among disparate systems and services? For example, the definition should allow for different applications to be considered more or less sustainable when looked at in comparison to another service, at least within certain dimensions of sustainability.

RQ2.1 What dimensions of sustainability are the most relevant to businesses when evaluating IT systems and how does this compare to other values of IT systems? By answering this question, a better picture of how sustainability can be used for evaluation will be created when it comes to business strategy.

RQ2.2 What benefits can be gained from evaluating software sustainability and what is required from a business standpoint for it to be beneficial? The last question aims to answer if any of the work required for the evaluations is worth it for the stakeholders and contributes to a more sustainable application. Since the case is for a business application, the time and manpower for proper evaluations need to be worth the benefits gained from it.

1.4 Outline

With that said, this paper will be divided into multiple sections. To start, an overview of the history of sustainable IT in Chapter 2 and a review of related work in the field in Chapter 3 will be conducted. This will help create a base for what aspects of sustainability should be considered and an outline of the first iteration of a tool that could be used. After this, in Chapter 4, the action research methodology used for the project will be covered. After this, a set of interviews and a workshop with Husqvarna employees, as well as external parties, will take place in order to refine the questions and areas that the tool covers, highlighted in Chapter 5 and discussed further in Chapter 6.

When looking at background and current practices, there will be several aspects to consider. Firstly, a history of common points of focus regarding sustainability and its evolution will be discussed. Then, an analysis of different frameworks used for sustainability analyses will be conducted, including the sustainability scoring tool by Orbus. After this step, Orbus will be directly consulted, and the initial iteration of the tool will be carefully reviewed based on previous findings.

Following the review of current practices, Husqvarna employees will actively participate in refining the sustainability scoring methodology. Here, stakeholders will be interviewed regarding the company's sustainability goals and what they want the scoring mechanisms to achieve. This will give insight into how a case company views sustainability issues and how these developing techniques can lead to a more sustainable organization. This step will also include reaching out to service managers who will be the ones who are using the tool in the future. The scoring system will be improved through the workshop and discussions by getting more perspectives on how the applications should be scored. The last step, the implementation plan, is where the final iteration changes to the assessment tool will be delivered to Husqvarna's enterprise architecture team, as well as Orbus. At the end of the report, findings and results will be discussed and reviewed, with an emphasis on future recommendations for final implementation.

2

Background

This chapter focuses on exploring different areas of interest regarding sustainability within software engineering by looking at how sustainability has historically been defined within this field.

2.1 Sustainability in IT

2.1.1 Socio-Technical Sustainability

The definition of sustainable IT does not have a clear consensus agreed upon by practitioners. Many different approaches to sustainable design have been brought forward through research, and different approaches place responsibility on different areas of the design process. Chitchyan et al. [7] build on the Oxford definition of sustainability as the ability to endure. They expand on this with the UN's definition of sustainability, "meeting the needs of the present without compromising the ability of future generations to meet their own needs"[1] and a model by Penzenstadler et al. [26] to characterize sustainability into five dimensions: economic, social, environmental, technological, and individual.

The first three dimensions are used in most industries, as they were characterized by the UN, but commonly do not include technical or individual dimensions. The economic dimension includes created value, profitability, and governance. The social dimension focuses on diversity, inclusiveness, and the sense of community created by a product or service. The environmental dimension is often the dimension that most people consider when looking at sustainability and includes resource management, energy use, biodiversity, and waste. The individual dimension was introduced by Goodland [14] and includes health, safety, personal development, and free will. The last dimension, technical, was introduced specifically for software development and includes traditional non-functional requirements such as maintainability, efficiency, and security.

The use of these five dimensions provides a more thorough exploration of the different effects that a product can have. By considering and applying these dimensions of sustainability during the requirements stage of the design process, it should

[1] www.un-documents.net/our-common-future.pdf

lead to more sustainable design. However, as previously mentioned, there is research that sheds light on the complexities associated with integrating sustainable design principles into software engineering practices [7]. The results by Chitchyan et al. findings underscore prevalent challenges within the industry, including the limited comprehension of sustainability concepts among software practitioners and inadequate awareness of the potential benefits. They also argue that the existing professional norms do not inherently support sustainable outcomes. These obstacles present significant barriers to the adoption of sustainability design in software engineering processes.

This outlook on sustainable IT being more than an environmental question is further supported by Dao et al. [11]. They discuss the emergence of a triple-bottom-line perspective of sustainability. The Triple Bottom Line (TBL) is based on the idea that companies owe more to stakeholders than simply economic performance (the bottom line being the net income of a company at the bottom of an accounting sheet). Instead, companies should be equally focused on environmental and social performance [12]. They argue that companies can benefit economically in the long term by balancing their economic goals with their environmental and social goals. Furthermore, they acknowledge that most recent research is focused on the environmental sustainability of IT but that this misses a critical area of sustainable development.

2.1.2 Environmental Sustainability in IT

While the previously mentioned research incorporates social and economic or governance factors into their definitions of sustainability, this is not always the case. Oncel [16] focuses on evaluating the energy efficiency of IT systems, as this is an area that can often prove difficult when comparing multiple systems. Khuntina et al. [19] look at evidence of sustainable IT from an emerging economy. They argue that in emerging economies, investing in green IT (environmentally sustainable) is a possible first step to creating more overall sustainable and profitable businesses, and provide evidence of businesses in India that saw positive externalities (in the form of social sustainability) from such investments.

In a conceptual framework developed by Musango & Brent [23], a similar conclusion to Khuntina et al. is brought forward. They argue that society and the economy are directly dependent on the resources provided by the environment and are therefore a priority in sustainable IT development. This is based on a model developed by Mebratu [22], which argues that the model used for the TBL approach to sustainability still separates the three systems: economic, social, and environmental. He instead argues that the ultimate goal of sustainability should be the full integration of all three systems as shown in Figure 2.1.

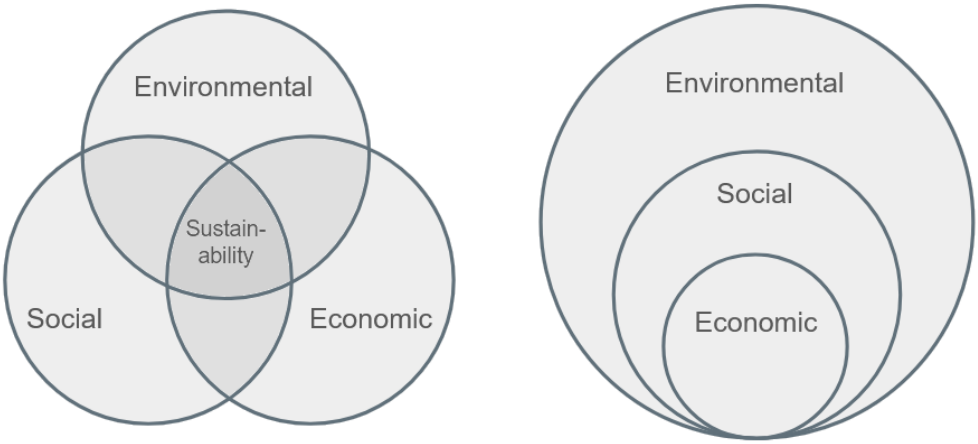


Figure 2.1: The Triple Bottom-Line view of sustainability (left) and the cosmic interdependence model of sustainability adapted from Mebratu [22] (right)

2.2 Sustainability Reporting

While previous sections highlight the potential benefits of investing in sustainable software engineering, it may not prove to be beneficial from a purely economic point due to the large investments that may be required. The accelerating area of sustainability reporting, however, may act as a catalyst to drive more sustainable investments.

Sustainability reporting has noticeably increased year by year since the first sustainability report in 1989 [20]. In the beginning, this was done voluntarily for several reasons highlighted in research by Kolk where companies were surveyed during the 90s and early 00s [20]. Motivations for these sustainability reports included, "enhanced ability to track progress against specific targets", "greater awareness of broad environmental issues throughout the organization", "improved all-round credibility from greater transparency", "ability to communicate efforts and standards," and "reputational benefits, cost savings identification, increased efficiency, enhanced business." As companies noticed the benefits, the growth of sustainability reports started to grow [20].

While the growth of sustainable reporting was voluntary in the beginning besides the pressure from stakeholders for better transparency, a change in EU legislation in 2014 increased pressure on larger companies within the EU [1]. As part of a movement within the EU to increase corporate social responsibility and transparency of larger companies within the EU, the Non-Financial Reporting Directive was established [1]. This legislation made it mandatory for larger companies to publish non-financial, sustainability reports that highlight progress within ESG dimensions, along with regular reports, as a way to promote sustainable business practices.

While this legislation initially only targeted companies that filled certain criteria based on size or if they were public-interest entities, it would later be amended to

form a new directive, the Corporate Sustainability Reporting Directive (CSRD) [3]. This new directive was created as part of the Green Deal in 2020 and encompasses a greater scope of businesses that will have to report depending on their size. The topics and areas that have to be reported upon are covered in the European Sustainability Reporting Standards (ESRS). These can be seen summarised in Figure 2.2.

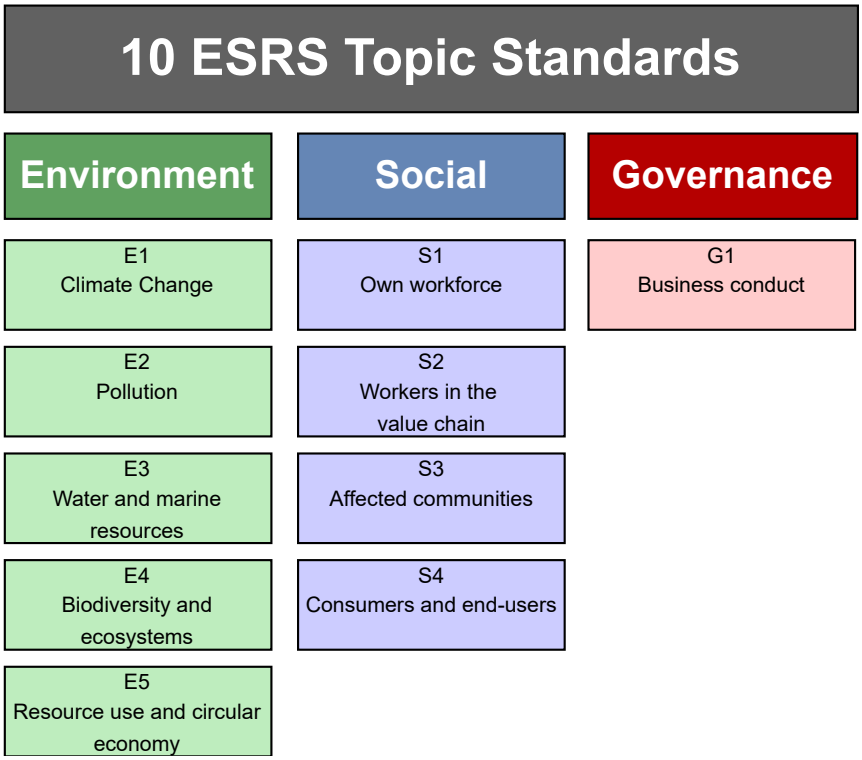


Figure 2.2: European Sustainability Reporting Standards Topics

According to Husqvarna's Sustainability Report 2023, they will be moving towards CSRD-based reporting during 2024. While the sustainability analysis of Husqvarna's application portfolio may not need to be reported as a part of this shift if it is not within the scope of Husqvarna's sustainability reporting, it may act as a driving factor in more sustainable actions within Husqvarna's IT infrastructure. Due to this, these topics may be increasingly relevant to address in a future scoring system.

2.3 Industry Views and Actions

The Orbus-developed tool is based on research that has been collected by several consulting firm reports in different fields. The current software technology landscape has proven to be aware of the importance and benefits that can be gained from sustainable practices but has underperformed when it comes to acting on this knowledge [4]. Another report also stresses the importance of mapping sustainability initiatives to the SDGs as a way to build trust with stakeholders [2].

A report from 2022 surveying 268 different decision-makers regarding ESG practices found that there were definitive benefits to investing in it [10]. The report found that companies that were ESG compliant saw more benefits from their actions than those who chose to focus on other areas. As mentioned previously, reduced risk has been a proven benefit that increases investment and leads to more resilient software solutions, which improved ESG actionability can lead to. The findings also show that the cost of ignoring such actions can lead to governmental penalties, a competitive disadvantage, and slower innovation. However, the survey also highlights a common issue, that correlates with previous research, which is that companies lack ESG data management. By focusing on ESG performance and maturing sustainability awareness, companies can close the gap by finding areas of improvement.

There has been a growing emphasis within the research community on integrating sustainability principles into software engineering practices from different workshops and conferences with expertise in the field [27]. Discussions and research underscore the importance of innovative approaches to bridge communities and promote sustainability in interaction design, as highlighted by the International Workshop on Requirements Engineering for Sustainable Systems [24]. Key takeaways include the need to transfer sustainability research into practice, integrate the public in research processes, and address challenges like privacy, transparency, and socioeconomic disparities. Industry perspectives stress collaborative efforts and technology adoption for meaningful impact. By engaging diverse stakeholders through discussions like these, software engineers can develop environmentally conscious and socially responsible software systems that align with broader sustainability objectives.

3

Related Work

This chapter will focus on related research and methods that have attempted to assess the sustainability of software or implement a solution for measuring the sustainability of different software solutions. It will also discuss the possible drawbacks and advantages of each approach to sustainable software engineering. Even if none of these solutions are directly applicable to this project, there are takeways from them that can be considered when iterating the sustainability tool

3.1 Sustainability Evaluation Techniques

3.1.1 ESG Scores

A system that builds on the idea of a TBL approach to company goals is ESG scoring. ESG (environmental, social, and governance) scores were initially created for financial companies to assess their performance in these areas, much like the TBL approach [8]. It was later adopted by other industries after companies saw the scores as a way to enhance their reputation, reduce legislative pressure, lower financial risk, and attract more capital. This evaluation approach also comes with limitations since there is no standard for the scoring. It is instead based on individual ESG goals for companies [9].

There is evidence that corporate social responsibility by considering ESG factors can have a positive impact on businesses' valuation by reducing risk in a study from 2016 [29]. This study, however, looked at how each dimension impacted risk individually. They found that the social dimension had the most significant effect on reducing both systematic and idiosyncratic risk. Higher environmental performance only affected idiosyncratic risk in most industries that were not environmentally sensitive. One interesting finding from the research was that higher governance performance did not have a significant effect on risk.

Another issue that is brought forward when looking at sustainability in IT is that it can lead to vague results that make it hard to directly compare two products. Therefore, Kern et al. [18] propose another method that would allow for comparison. They suggest a standardized set of criteria, based on the energy use, hardware requirements, and user experience of software. This would allow software to be directly labeled as more or less sustainable than other software. This can prove

difficult, however, as gathering technical information regarding the environmental impact of technology is a practice that is oftentimes ignored in the technology sector. A report from 2022 showed that only 55% of companies that they looked at knew how much carbon its technology emitted across digital tools, apps, IT systems, and data centers [4].

One issue for this project is that, while ESG ratings can be compared for firm valuations, it is not fit to to compare specific software, especially between companies since there is no standard in this area. Hughes et al. [15] propose an Alternative ESG rating which would allow for more standardised ratings but none of which have been applied at large. There is also the consideration that this measurement was not designed specifically for IT and has merely been adapted which can be cause for concern when looking for the best approach to analyzing software.

3.2 The Sustainability Awareness Framework

The Sustainability Awareness Framework (SusAF) was developed specifically for IT practitioners to consider and address the sustainability effects of their software solutions [5]. Taking into consideration the five dimensions of sustainability previously mentioned, the framework is designed to visualize short- and long-term impacts of software and the relationship between different dimensions by mapping out first, second, and third-level effects. Each dimension is also divided into a set of topics which the questions are directly aimed at.

Each topic and corresponding question in the SusAF have all been traced out to specific SDG targets [30]. An SDG target is a more concrete action that would contribute to a goal. The traceability of each question to a direct sustainability action makes the framework a well-reasoned tool for evaluating the sustainability of software solutions.

While the framework allows for a more holistic approach to sustainability, it does have drawbacks that are relevant to this paper. For one, the framework requires significant time for software solutions in a project where the goal is to be able to evaluate a large number of applications without major time investments for each application. Furthermore, as of now, there is no way of quantifying impacts, even if this is a goal for future development of the framework [5].

3.2.1 SusAF Case Study

In a case study by Lieu et al. [21], the application of SusAF provided a structured approach to understanding the sustainability impacts associated with a water analysis software product. Vattn, a software startup focused on water quality analysis, used SusAF to assess the sustainability implications of their solution across the the five dimensions.

Initially, Vattn identified the need for a comprehensive sustainability assessment to ensure their software not only delivered accurate and useful water quality data but

also aligned with broader sustainability goals. By applying SusAF, they were able to visualize both the short-term and long-term impacts of their software, considering various direct and indirect effects.

During the evaluation process, Vattn mapped out first, second, and third-level effects of their software solution. The study showed how the use of SusAF contributed to the start of a discussion regarding the impact of the software. It also helped provide activiteies that could help mitigate negative impacts or improve postive impacts. Overall, the study was beneficial to Vattn accroding to the report [21].

The Vattn case study demonstrated the practical application of the SusAF framework, showcasing how structured sustainability assessments can guide the development of more sustainable software solutions. While it differs slightly from the goals of Husqvarna, who wants a numeric rating of applications instead of actions that would improve sustainability, the study demonstrates one example of where the simply the introduction of sustianability assessments can increase awareness of the topic, which would make future changes more accessible.

4

Method

This chapter will go more in-depth into the methodology employed in this study. Multiple approaches to software engineering research can be used for cases like this and choosing the most fitting one is a crucial step when planning the process [32]. Since this study will incorporate research into industrial practice and use findings to improve a specific tool, an action research methodology was chosen.

Action research is a growing methodology within software engineering [31] since it has been identified as a way to allow for new research to impact new technology and vice-versa. The essence of the methodology is to implement changes based on research, observe the impact of the changes, and make improvements based on the results. This falls under the umbrella of "Field Experiments," though on the more obtrusive end of them [32]. The advantage of the method is that it allows for the development of practical solutions in real-world contexts, with the downside being that the solutions can be case-specific. Nevertheless, it has been identified as the optimal methodology to comprehensively explore sustainable IT solutions within Husqvarna Group.

In action research projects, several cycles of improvement upon one problem are conducted until research concludes, either in a final solution or findings that can lead to future work [31]. Each cycle also consists of five phases that can be seen in Figure 4.1: diagnosing, action planning, taking action, evaluating, and learning.

Each phase can be described as follows:

Diagnosing The first step of each cycle outlines the current problem aimed to be solved. This is achieved through looking at the current state of the project and previous research. This can also link the cycle to answer research questions.

Action Planning This step aims to create a way of answering the diagnosed problem identified in the previous step. The plan should answer how, when, and why the chosen action plan will solve the problem.

Action Taking This step follows the steps laid out in the action plan. It is in this step that data collecting is prepared and conducted through some form of intervention.

Evaluating Here, the data collected is evaluated and assessed in order to properly

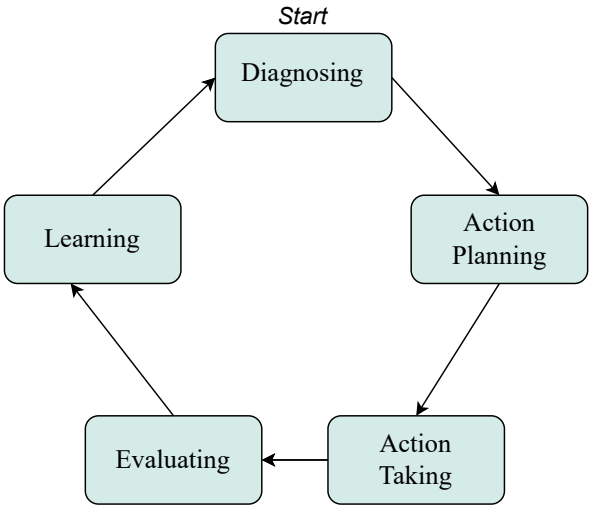


Figure 4.1: Action Research Cycle

address the problem of the current cycle.

Learning The last step of the cycle summarizes what has been gathered from the cycle and whether it has solved the problem. It is also in this step that new information that may be used in the next cycle's diagnosing phase is prepared.

Staron [31] also highlights that there are two common ways to structure action research reports depending on how important the findings of each independent cycle are and how results are presented. If the report is more concerned with the overall results and learnings of the entire project, the results section should summarize the results of all cycles. The other approach is for reports that are more focused on the actions taken, in which the results should be presented cycle for cycle. Considering that the overall aim of this research paper is to expand and improve upon a sustainability scoring tool to a final iteration, the results will be presented as a summary of findings, without focusing too much on the cycles.

4.1 Action Research Cycles

While the number of cycles necessary for this project was not decided from the start, as it is an iterative process, it ended up being three cycles that would provide an answer to each research question. Each cycle was therefore aimed to gain insight into each question, all while improving upon the sustainability evaluation tool. An overview of each cycle can be observed in Table 4.1.

Diagnosing	Action Planning	Action Taking	Evaluating	Learning
Cycle One: How can the sustainability of software solutions be rated numerically?	A literature review of common practices and approaches to evaluating the sustainability of software tools that already exist.	A review of different frameworks was conducted. This included looking at the different views of sustainable software and the pros and cons of each. A deep dive into the planned analysis tool was also conducted through an interview with the developers at Orbus.	The results showed that several views valued the dimensions of sustainability differently. The currently planned analysis tool is also identified as a suitable starting point if it is properly modified to fit this case through future cycles.	This cycle detected several areas that needed to be considered before implementing a solution. The main takeaway is that it is up to each company to decide what they value and want to put time into. Any solution to the problem will be based on internal goals and knowledge which can later be used for a numerical score.
Cycle Two: What aspects should be considered when developing the tool in the case of Husqvarna?	By interviewing stakeholders within Husqvarna, the current tool's scoring and analysis approach can be adapted to match the values and interests of Husqvarna.	An interview with a higher-up at Husqvarna, directly involved with sustainability goals, is conducted. A review of current Husqvarna sustainability initiatives is also looked at.	Several insightful comments on the current analysis tool, along with a summary of Husqvarna's future work with sustainability were gathered. CSRD was brought up as a potential area of future focus regarding the project.	A shorter cycle than the last but contributed significantly to learning more about what stakeholders want to know. It acted as an important step to make sure that the tool used reflects company goals and values.
Cycle Three: What information can be gained through an analysis tool? In other words, what do application owners know about their respective applications and what is their input on the current state of the tool?	A workshop and subsequent survey with service managers at Husqvarna would help answer the diagnosed problem. This hopes to answer if the service managers (who would be using the tool) have sufficient knowledge to answer the questions.	The workshop was conducted with 7 service managers who subsequently filled out a survey regarding their feedback to the questions and content of the tool.	The results of the workshop and survey highlighted areas that service managers lacked knowledge in as well as areas that they would generally not consider when evaluating applications. The results were discussed with the tool developer as well.	The workshop results led to final adjustments to what needed to be considered before implementing the tool, highlighting areas that need to become more central for future assessments.

Table 4.1: Action Cycles Overview

4.2 Weekly Meetings With Stakeholders

To ensure that the scope and goals of the project aligned with the company goals, weekly meetings with supervisors at Husqvarna's enterprise architecture department took place. This allowed research and findings to be directly reported, which allowed for feedback on the direction of the thesis. These meetings also allowed for clarification if questions popped up during any stage of the research.

It was also through these meetings that contact was made with other stakeholders. Extra meetings with the product owner of the analysis tool and the sustainability lead of Husqvarna were both initiated in these weekly meetings. The workshop was also made possible by contacting relevant service managers through supervisors who had access to and knowledge about who should take part in the workshop.

Staron [31] would consider this both the "reference team" and the "management team" which is common in action research projects. The reference team acts as a guide for the research and looks over findings to reduce bias introduced by the researcher [31]. The supervisors acted as the management team by providing access to the different tools that would be looked at and, in turn, controlling the scope of the project.

Furthermore, at least one supervisor was present during every interview and workshop with employees, providing answers to questions, as well as making sure that the semi-structured interviews covered areas of interest to management.

4.3 Literature Review and Framework Comparison

The study commences with an extensive literature review to establish a theoretical foundation and identify existing frameworks and practices in sustainable IT. This review encompasses academic publications, industry reports, and relevant conceptual frameworks. Special attention is given to frameworks used for evaluating sustainable products and practices. Through critical analysis and comparison, the study evaluates the applicability and effectiveness of these frameworks within the context of Husqvarna's sustainability goals and IT infrastructure.

The central framework used as a starting point is the set of initial questions that are part of the Orbus tool. Since these questions were designed to be used by the tool, they provide an ideal starting point for evaluations. These questions will then be evaluated from a research perspective based on findings from the related work section. They will also be directly compared to other frameworks to detect areas that are underdeveloped or overvalued. Through these steps, the framework and questions will be adjusted accordingly to provide more accurate and useful information from the sustainability evaluations, in order to address the research questions.

The list of initial questions is as follows:

- Environmental sustainability questions:
  - **EQ1:** To what extent does the application offer features that promote or enhance environmental sustainability (e.g. power-saving modes, efficient resource use, green software development...)?
  - **EQ2:** Have any steps been taken to minimize the environmental impact during the application development and deployment processes (e.g., using energy-efficient servers, cloud services, optimizing code for performance, etc.)?
  - **EQ3:** Is the application designed to be usable in the long term (possible scope expansion, scalability, and sustainable deployment), as opposed to being chosen or deployed as a semi-temporary solution to be replaced in the future?
- Social sustainability questions:
  - **SQ1:** Do the deployment and running of the application in your organization involve, directly or indirectly, local communities and groups, rather than rely on global or decentralized organizations?
  - **SQ2:** Does the application adhere to any accessibility standards with multi-lingual support access to allow for a diversity of people to use it if they want to?
  - **SQ3:** Does the application support hybrid work or digital collaboration, reducing the need for physical resources and travel while increasing accessibility and participative work?
- Governance sustainability questions:
  - **GQ1:** If any sustainable considerations have been actioned regarding environmental, social, or governance lens (energy consumption, diverse accessibility, information security...), to what extent do you measure them today, directly or indirectly?
  - **GQ2:** How confident are you that the application includes mechanisms to sufficiently protect personal information and enterprise data?
  - **GQ3:** Do you see any environmental, social, or governance-related risks that would have a high impact on the enterprise landscape and the business in general? In doubt, please refer to your risk management classification framework.
- Process sustainability questions:
  - **PSQ1:** To what extent does the functional scope of the application support your activities (no rarely used features) with limited functional re-

dundancies? (These could be areas to streamline and save resources)

- **PSQ2:** To what extent do you have a plan in place to responsibly decommission the application, including data disposal and hardware recycling?
- **PSQ3:** How do you evaluate the sustainability level of awareness and engagement of the external parties involved in the application lifecycle?

4.4 Interviews

Qualitative research methods in the form of interviews were employed to gather insights from key stakeholders within Husqvarna. Participants were selected based on their roles within the organization and their expertise in either sustainability or software tool management. Semi-structured interviews were conducted to explore stakeholders' perspectives, experiences, and expectations regarding the integration of sustainability practices into software management. Since the interviews' goals were effectively to dig into the interviewees' knowledge, the semi-structured approach was chosen so that questions could build on top of each other. According to Ghazi et al. [13], this provides more in-depth knowledge since the researcher would not be able to prepare in-depth questions before the interview starts.

The first interview took place with the assessment tool owner at Orbus. This interview was devised to get insight into how the questions were created and mapped which would contribute to RQ 1 and 2.2. The interview was structured as follows:

1. Gather information about what research was used to develop the tool.
2. Explain how the questions are used to score applications, including the calculations.
3. Why the tool was created and how it can be used to create business value for companies.

The interview gave several resources that would be, gave valuable feedback regarding the definition of sustainable software from another perspective, and gave insight into areas of improvement that could be implemented into the tool. The interviewee also helped as a point of contact to relay feedback as the project moved forward.

The second interview took place with a key stakeholder within the sustainability department at Husqvarna. As previously mentioned, Husqvarna has not worked with sustainable IT previously, so the interview would work as a stepping stone to map Husqvarna's current sustainability goals and ambitions to this new area. The interview was structured as follows:

1. Gather information about Husqvarna's current work within sustainability
2. Evaluate the assessment tool's questions and dimensions from Husqvarna's perspective. This step highlighted areas that were seen as more essential to current operations, and which areas may not be as important to focus on.

3. Get suggestions of areas which Husqvarna would like to focus more on. This step would highlight questions that were possibly missing from the current framework.

4. Weigh each dimension in order of importance.

The interview laid the foundation for how the tool should be restructured to meet the goals of the company. It also gave valuable results regarding RQ 2.1 and 2.2.

These interviews, along with the weekly meetings, helped form and guide the scope of the project and the first two action research cycles to improve upon the tool. They also contributed to all three research questions in some capacity.

4.5 Workshop

The workshop was conducted as a key component of the third action research cycle to assess the quality and relevance of the questions within the sustainability tool. Participants were selected based on relevance as determined by the supervisors at Husqvarna in charge of enterprise architecture, also known as the non-probabilistic judgment sampling [13]. The selection criteria of participants included knowledge about the software, the importance of the software, and the availability of the participants. This was done to check the value of the tool with critical applications, as determined by the supervisors.

The workshop was designed as follows:

1. Workshop:
    - Introduction to the topic and relevant.
    - Explanation of the tool, the dimensions, and the related questions.
    - Evaluation of the questions by getting verbal feedback on how much the participants know about them.
2. Survey(following the workshop):
    - Evaluation of the questions by getting answers regarding the participants' respective applications.
    - Feedback on questions that are not part of the tool but have been added in previous cycles.
    - Suggestions and areas of improvement based on their overall experience.

Important to note is that the workshop was not focused on evaluating the service managers' respective tools, but instead the quality of the evaluation questions in its current state. Through the workshop evaluation, a more applicable version of the tool and its benefits could be completed based on the various sources of feedback.

4.5.1 Survey design

Ghazi et al. [13] highlight steps that should be taken in survey design. The goal, sampling, and contents have already been highlighted as they are shared with the workshop overview. The survey design, evaluation, and analysis are however also steps that should be prepared. As the workshop would be online, the survey was also online and would be sent out to participants after the workshop concluded. Since it takes place in the second half of the project, the workshop and survey questions will not be predetermined but instead built around findings from the interviews and literature review.

The survey will contain close-ended questions (Likert scale questions) as well as open-ended questions where participants can provide written feedback on any unclarities as well as general feedback and suggestions. Both Ghazi et al.[13] and Kasunic [17] mention that the choice of even or odd numbered choices for Likert scale questions needs to be considered based on what the question aims to find. Since part of the findings should highlight questions that are unclear or hard to answer, an odd scale would be best, allowing participants to choose middle options for unclear questions. These questions could then be looked at, if they need rewording for example.

For pre-evaluation, the survey was sent to the supervisors as they had a better estimate of the service-manager knowledge level and the aim of the project. During the second half of the online workshop session, the survey was also covered with participants. The reason for this was to make sure that the aim of the survey was clear and if there were any questions regarding concepts, they could be answered before the survey was completed to garner higher quality responses. Lastly, the analysis would be done through a thematic grouping of written responses [31] along with illustrative extracts [6] and data visualizations of the close-ended questions to gather the views and knowledge level of the service managers. A sample question from the survey can be seen in Figure 4.2 which was distributed through Husqvarna using Microsoft Forms[1] and the full survey can be seen in Appendix B.

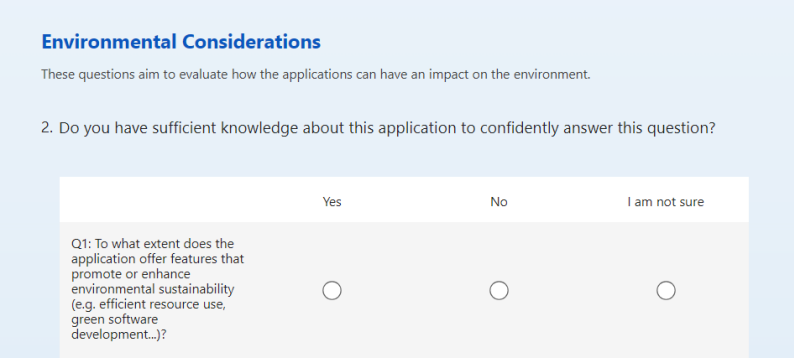


Figure 4.2: Sample question from survey

The survey was later analyzed in two ways. Numerical data from the Likert rat-

[1]Microsoft Forms

ing was visualized in Microsoft Excel[2] and qualitative data was analyzed through thematic coding as suggested by Staron [31]. For this step, codes were identified in quotations from the participants which were later mapped to themes. In the Results chapter, only the themes are presented.

4.6 Implementation Plan

Building upon insights gathered from interviews and workshops, the study proceeds to the deliverable phase. The scoring system is improved upon based on findings and prepared to be implemented into Husqvarna's IT application master. This process includes refining the scoring tool based on feedback and educating employees at Husqvarna IT architecture department about future implementation. In this phase, feedback from stakeholders is actively solicited to ensure alignment with organizational goals and address any emerging challenges or concerns. While implementation of the tool may be further delayed depending on Husqvarna's satisfaction and preparedness, the research and improvements will serve as an introductory step that supports the improvement of more sustainable IT solutions at Husqvarna.

4.7 Data Collection Summary

The full summary of the number of participants and their roles, the number of sessions, and the length of the sessions are summarized in Table 4.2 below.

Cycle	**Technique**	**Partipants**	**Duration**
First	Interview	Two Orbus employees in charge of the assessment tool Two Husqvarna supervisors	Two 30-minute online sessions
Second	Interview	One Husqvarna representative from the Sustainability department Two Husqvarna supervisors (first session) and one supervisor (second session)	One 30-minute online session and one 60-minute online session
Third	Workshop	Six Husqvarna service managers One Husqvarna supervisor	One 45-minute online session
Third	Survey	Six Husqvarna service managers	Filled out during own time (7-minute average)

Table 4.2: Data collection summary

[2]Microsoft Excel

5

Results

This chapter will highlight the results from the framework comparisons, interviews, and workshops. It will also show how the findings affected the development of sustainability analysis tool after each research method.

5.1 Action Research Cycle Overview

As the project progressed, the multiple action research cycles were completed. They all followed a similar structure where a problem in the current iteration was diagnosed, a plan to solve the problem was completed, and the results were analyzed for the next cycle.

Summary of the Action Research Cycles

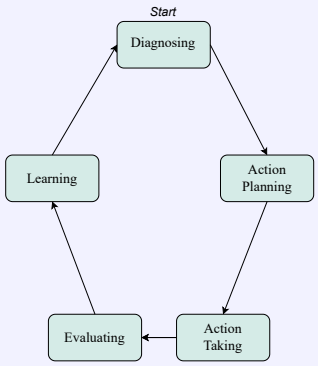
Diagnosing: Identifying areas of improvement in the current iteration of the tool

Action Planning: Identifying who or what can be consulted to improve the diagnosed problem.

Action Taking: The research technique (interview, literature review, workshop) used to gain information that would improve the current iteration of the tool.

Evaluating: Consideration of results and how they can be used to improve the tool by removing or adding aspects that are more important to Husqvarna.

Learning: Looking at and reviewing the new iteration of the tool's framework and looking for other areas that could be improved upon.



5.2 Initial iteration

At the start of the project, an initial implementation for an application sustainability tool was presented. Developed as an extension to Husqvarna's current application master, it was determined as an optimal starting point for development as it was already integrated into the infrastructure at Husqvarna. However, to understand how it was developed and to make sure that it is validated through proper research, a deep dive with the tool's developers was set up.

The structure and findings from the semi-structured interviews can be seen in Table 5.1. On top of this, a detailed breakdown of how the tool is used was given, which is mentioned in the tool introduction in Section 1.2.2.

Guiding Questions	**Interview Findings**
What frameworks were used to develop the sustainability scoring questions	ESG scores were the biggest inspiration SAASB, GRI, and CSRD were also considered
Why was security added as a question?	Data safety and ESG standards touch on security concerns
How does the tool calculate scores?	*Explained in a walkthrough:* Each question is ranked on a scale of 1 to 5 and is averaged out for each dimension. The total score is averaged out for each dimension but can be weighed depending on which dimension is prioritized.
Why was the tool created?	Thought of as a way to boost communication around sustainability A way to surface sustainability questions in strategic decision making or at least to consider it Also, it is a problem is that tools are usually extensive and time-consuming so this could be a more straightforward system

Table 5.1: Tool Developer Interview Findings

Another result of the interview was reading the different industry reports that the tool was based on. These included a multitude of industry views that were highlighted in Section 2.3. Some key takeaways from these reports can be seen in Figure 5.2 This research highlights some of the challenges of implementing more sustainable practices but also the benefits that can be gained from it.

Report findings
While 90% of business leaders value sustainability, only 60% have a sustainability strategy[33]
Insufficient ESG data is the most significant challenge for firms[2] Immature internal ESG data management holds firms back[2] Investing in ESG yields transformational benefits[2]

Table 5.2: Industry Report Findings

RQ1

Research Question 1: *What criteria can be established to define sustainable IT and data, facilitating meaningful comparisons among disparate systems and services?*
The results from the initial assessment model give a framework for scoring different software systems. Here, based on industry reports and collaboration with other businesses, the framework separates the score into different dimensions with questions that can be answered on a scale of 1 to 5. A total score from 1 to 5 can then be calculated for each application. However, the scoring may still vary from business to business. Each company can identify areas that they deem to be more important which they should include and weigh higher than other areas. This does not improve the ability to compare the sustainability of applications between different businesses but can be used to communicate the sustainability of different applications.

5.3 Comparison with other frameworks and literature

After the base iteration of the tool had been explained and validated, it was further analyzed and improved upon by comparing it to previous research, related work, and other frameworks. This process helped further establish how the current iteration lined up with sustainability theory. When comparing the questions directly to other frameworks, specifically ESRS and SusAF, noticeable differences were highlighted. These differences were considered when making adjustments to the tool to find areas that were possibly underrepresented or should not be considered.

5.3.1 Alignment with theory

Looking at the structure of the tool as it is, it is based on ESG metrics to calculate the score. Without added weights, each dimension is weighed equally in the score and contains three questions each. It therefore focuses on all aspects of sustainability, not just the environment. The fourth added dimension, process sustainability does not align with one specific dimension, but instead focuses on third parties, accountability, and lifespan.

One key difference with similar work is the focus on sustainable maturity. Instead of looking at the effects that the software has on sustainability issues or providing an ESG rating, the tool assesses the current awareness and inclusion of sustainability issues. In other words, it assesses to what extent the application considers sustainability questions in its design and use. Considering that research shows that there is difficulty in comprehending how sustainability can be incorporated into software design, this approach to rating sustainability may be optimal as a first step in more sustainable applications.

5.3.2 Comparison with SusAF

The Sustainability Awareness Framework contains a lot of similarities with the application sustainability assessment tool. Both have designed their questions with concern to the SDGs, focus on multiple dimensions of sustainability, and to provide an awareness of the sustainability of a product. Their differences come from how they approach the issue. The SusAF is a more in-depth analysis that maps out not only the socio-technical effects of a product on multiple levels but also how the effects relate to each other between dimensions. While this creates a more in-depth picture of the overall sustainability of an application, the process is time-consuming and would not apply to the tool as it is.

With that said, there are several takeaways to be had from the comparison. When looking at the list of questions for two different frameworks, the original questions in Appendix A.1 and the Sustainability Awareness Framework in Appendix A.2, the similarities and differences can be looked at to find areas that are possibly underdeveloped in Orbus' or areas that should weigh less.

There are several areas where the two frameworks share a focus. Both frameworks cover:

Energy use Emphasize efficient energy use and the promotion of more sustainable practices.

Social Sustainability Consider social diversity, inclusiveness, and creating a sense of community.

Governance Promote enterprise performance in the governance dimension.

The responsibility of where the two frameworks differ mostly lands on the simplicity of the Sustainability Lens. Areas that the SusAF promotes that the Sustainability Lens does not include:

Environmental Material use, biodiversity, land use

Logistics For example, reducing the need for certain travel or delivery options.

Social Sustainability Trust, participation and improved communication, and equity.

Economic Sustainability Value creation, customer relation management, and innovation.

Individual Sustainability The individual dimension which includes health, learning, safety, and free will.

Technical Sustainability Part of non-functional requirements.

The comparison highlights some of the shortcomings that the current tool has which will be considered in future iterations. The advantage of considering the SusAF questions is that they have all been validated by mapping them to particular SDG actions. This provides further validation of the questions if implemented.

5.3.3 Comparison with ESRS

The same comparison can be done with the European Sustainability Reporting Standards previously shown in Figure 2.2. Once again, they share similarities as the ESRS topics are developed as part of the Green Deal which includes support towards the SDGs. They are also divided into three ESG categories. Here, however, one difference is how the two frameworks weigh the different areas. Half of the ten areas that the ESRS touches upon are environmental and four of them are social.

The ESRS standards that align with the initial iteration of the tool are:

ESRS E1 Climate Change: Greenhouse gas emissions, climate risks, and mitigation strategy.

ESRS E5 Resource use and circular economy: Sustainable resource use and circular/recycling practices.

ESRS S1 Own workforce: Issues related to human rights protection.

ESRS S3 Affected communities: Ethical business practice, anti-corruption, and workplace compliance.

The other five standards are either partly missing or completely missing from the tools' current questions:

ESRS E2 Pollution: waste management and pollution control.

ESRS E3 Water and marine resources: Water use, conservation, and aquatic impact.

ESRS E4 Biodiversity and ecosystems: Impact on ecosystems and biodiversity conservation efforts.

ESRS S2 Workers in the value chain: Employee rights and workplace conditions.

ESRS S4 Consumers and end-users: Product safety and consumer rights.

ESRS G1 Business conduct: Governance structure and stakeholder engagement.

The areas missing are mostly within the environmental dimension. These missing standards can reasonably be omitted because a majority of applications will not have any observable effects in these areas that a service manager could assess. ESRS S4 is also more related to consumer products which is not an area that the application portfolio considers in this case. Addressing ESRS S2 and G1 are however two areas that could be included. These are also two areas that are highlighted in the SusAF, namely individual sustainability and economic sustainability. Furthermore, their inclusion could be directly beneficial to future CSRD considerations.

From the findings in this cycle, the following additions to the framework were made:

- From SusAF:
  - The environmental aspect of improved logistics
  - The social aspect of improved communication throughout the value chain
- From ESRS:
  - S2 on workers in the value chain (in combination with the SusAF suggestion)
  - G1 on business conduct

5.4 Internal sustainability reporting input

After the initial review of the questions, the interview with a Husqvarna responsible for their sustainability reports could take place. The interview covered the future of Husqvarana's sustainability plan, the current stance regarding sustainable IT, and the feedback on the current iteration of the tool.

Two points that were brought up regarding the current design are a lack of third-party evaluation and two-sided questions without a clear answer. The first point was highlighted as a consideration since, as a company, there exists a risk in purchasing software solutions from companies that harm the environment or disregard social issues. Instead, the suggestion of improving information about the source company could be an important step to promote more sustainable decision-making regarding vendor selection.

The other point was regarding the two-sided nature of several questions. For example, an application that involves local communities in development or use could also be a negative if it is simply done as a way to cut costs by moving operations to cheaper countries. In some cases, this may be a positive, but it also runs the risk of supporting a lower standard of working conditions and manipulative work. The full list of takeaways from the interview can be seen below in Table 5.3.

Guiding Questions	Interview Findings
What is the current status of environmental practices related to IT at Husqvarna?	Green IT discussions have occurred, but they're not currently active as a choice. Currently, the closest action is assessing hardware suppliers for sustainability. Criteria include CO2 emissions, environmental practices, and human rights.
Thoughts on current environmental sustainability questions	Tools may face penalties for not fulfilling their intended functions, for example, if they do not have power-saving modes. Energy and resource efficiency are considered the most crucial. Long-term solutions might seem redundant; however, they're still considered, especially for evaluating decommissioning or selecting better tools. One suggestion is to evaluate sourcing company practices, including servers and production.
Thoughts on current social sustainability questions	Inclusion can have drawbacks, like using local communities to reduce labor costs or standards but diversity and inclusion are important Hybrid working arrangements could impact community and well-being. Instead, a focus on work/life balance could be considered. One suggestion could be a section on sourcing company working conditions or product contribution to human rights.
Thoughts on current governance sustainability questions	Currently, security isn't a focus Some suggestions for improvements include clarifying what accountability means for sustainability, ensuring that the software complies with company policy, and seeing if the source company supports UN Global Conduct.
Thoughts on current process sustainability questions	Decommission plans may not always apply or be relevant. One suggestion is to identify if the application has a planned owner for all lifecycle stages
Other suggestions	Adding a question if CSRD reporting capabilities are planned for the tools.
What is the order of importance for each dimension according to you?	If the suggestions are incorporated the most important dimension is as follows: Environmental, particularly energy and resource use, social, especially human rights, process sustainability with a larger focus on the sourcing companies' policies and environmental impact, and governance last.

Table 5.3: Husqvarna Internal Sustainability Interview Findings

5.4.1 Consideration of CSRD

The interview also covered the topic of CSRD. The new regulations on EU-based businesses had already affected Husqvarna's sustainability reporting and would go into effect in 2024. This area highlights an area where the sustainability analysis tool could be beneficial for the business, as discussed previously in Chapter 2.

By incorporating CSRD topics into the sustainability tool, the EA department can start preparing for possible future reports regarding the application portfolio. When speaking with the interviewee this was further highlighted with the interest in business conduct. When purchasing software from third parties, they considered a code of conduct alignment as being a key topic that was currently missing from the tool.

RQ2.1

Research Question 2.1: *What dimensions of sustainability are the most relevant to businesses when evaluating IT systems and how does this compare to other values of IT systems?*
From interview feedback and industry reports, several common areas of sustainability were identified. CSRD preparation, application lifecycle (development, use, and termination), ESG data management, resource and energy use, work conditions, and accountability. As the required transparency of business operations is set to increase in the coming years, the ability to track and collect data regarding sustainable practices seems to be the most prioritized area of sustainable IT. For this to be possible, there needs to be increased accountability throughout an application's lifecycle. By improving contact and data collection throughout an IT product's lifecycle, sustainability reporting and sustainable decision-making can directly be improved. However, in the current state of business practice, decision-making around these issues is not a top priority, specifically within IT.

5.5 Service manager input workshop

5.5.1 Preparation

The following workshop would give feedback on the current iteration of the tool from the service managers who would be using the tool. When preparing for the workshop input from the previous steps was incorporated into the tool and the workshop.

First of all, a list of topics that should be incorporated into the tool was proposed and approved by the supervisors at the EA department at Husqvarna. The new topics were the following:

Logistics - E1 Taken from the SusAF framework, this environmental topic asks if the application improves logistics through decreased transportation or digitalization.

Work-life balance - S1 This area was brought up through the interview as a

counter to the already existing question regarding hybrid work. The interviewee suggested that hybrid work and social well-being may not be directly interlinked and could instead be restructured into a work-life balance question.

Customer/employee communication - G1 This question is covered in both the SusAF and ESRS (S3) frameworks.

General CSRD coverage - PS1 Here, the aim is to see if the application and/or the provider are prepared with reports for the future CSRD requirements.

Code of Conduct - PS2 Covered in both the interview and the ESRS standards, this is aimed at third parties and if their code of conduct aligns with that of Husqvarna.

Third-party environmental impact - PS3 This is brought up in the interview as a topic of interest. Husqvarna wants to know how much knowledge they have regarding third-party server use and overall environmental impact.

Accountability - PS4 This was an area of interest for the supervisors at Husqvarna who want to know if the application has a person responsible for all stages of its lifecycle.

These seven new topics, along with the original twelve were all touched upon during the workshop to evaluate their usefulness by future users.

The service managers that would take part in the workshop were chosen by importance regarding their respective applications, their knowledge of their applications, and their availability. In total, nine service managers chosen by the supervisors at the EA department were contacted for involvement with a pre-read containing background about the project and topics covered. On top of this, a slide-show presentation of relevant terminology and background was presented as well as time to ask questions about any topics that were unclear during the workshop.

5.5.2 The Survey

The workshop would allow for open discussion and questions regarding the sustainability analysis tool and how future implementation would look, but it would also conclude with a survey to be filled out by participants for feedback regarding the current iteration of the tool. The general overview of the survey is as follows:

1. What applications are you responsible for?
2. For each of the original twelve questions:
    (a) Do you have sufficient knowledge about this application to confidently answer this question?
    (b) Do you feel that any of the questions should be reworded or restructured? If so, how?

   (c) How important would you consider the questions when evaluating applications from an environmental/social/governance/process sustainability perspective?

3. For each of the seven new questions:

   (a) Do you have sufficient knowledge about this application to confidently answer this question?

4. Are there any questions/areas you feel are missing currently?

5. Are there any areas you feel should be less represented?

6. How would you rank the different areas in terms of importance for your application?

   The full survey can be seen in Appendix B

5.5.3 The Workshop

The workshop was divided into two sections, a presentation and an overview of the survey. During and after the presentation, feedback and discussions were encouraged to get insight throughout the process.

The presentation covered the background behind the development of the tool, its future integration and uses, an explanation of important terminology that would be used in the discussion and survey (ESG, SDG, and CSRD), and an introduction to the survey. Afterward, the survey was presented and gone through in case there were any questions or confusion regarding the structure or wording. It was also necessary to explain that this evaluation would be used to evaluate the quality of the questions, not to do an actual evaluation.

Out of the nine invited service managers, six participated in the workshop. The session lasted a total of 45 minutes after which the participants filled out the survey in their spare time. Feedback was gathered throughout the session and through the survey.

5.5.4 Results from the workshop

The feedback from the workshop can be separated into three parts: general feedback from the workshop session, written feedback from the survey, and question ratings from the survey.

The main feedback from the workshop and survey can be seen in Tables 5.4 to 5.9. Here, the feedback is separated by dimensions and identified themes. Since the requested feedback focused on identifying problems with the current tool, the themes are used to identify the reason for the problem. The common issues based on the feedback as themes were:

- **Knowledge:** Difficulty in answering the question due to lack of knowledge about the subject or if they are unnecessarily complicated
- **Commuication and Transparency:** A lack of information from vendors which makes answering the questions difficult
- **Policy:** The answer to the questions are more based on company policy rather than the application
- **Clarification:** Difficulty in answering due to wording or lack of detail in the question
- **Irrelevance:** Topic or questions are irrelevant to service managers

Theme	**Illustrative Extract Quotes**
Communication and Transparency	"Little to no contact with some vendors" "There is not enough information regarding external data-centres. We do not know if the company we are storing our data in green data-centers."
Irrelevance	"Multilingual support is not relevant in most cases since English is enough for most applications"

Table 5.4: Illustrative Extracts From the Workshop

Theme	**Illustrative Extract Quotes**
Knowledge	"The questions are too difficult to respond to as a service manager. It will be pure guess-work or a subjective response."
Communication and Transparency	"I don't know exactly how I can identify the vendor's effort in sustainability. It never a topic of our conversations with account managers" "I have no visibility about the development environment and green software development. If it's an in-house development then it might be easy to answer."
Clarification	"Need way more details in order to fully understand what you are questioning."

Table 5.5: Illustrative Extracts for Environmental Sustainability Questions

Theme	Illustrative Extract Quotes
Irrelevance	"When it comes to accessibility usually that not asked for the function is way more important"
Clarification	"What are local communities are those the same as an application team that works with the application?" "Overall using easier words, or maybe a bit background regarding sustainability"
Policy	"We as a company decide whether an application should be accessible from remote. The sensitivity of data and company policies might not tolerate an application to be available remote but the application itself supports the remote function."

Table 5.6: Illustrative Extracts for Social Sustainability Questions

Theme	Illustrative Extract Quotes
Clarification	"The questions are very hard to understand and need to be rephrased so they can be better mapped to business applications"

Table 5.7: Illustrative Extracts for Governance Sustainability Questions

Theme	Illustrative Extract Quotes
Communication and Transparency	"Can't answer these questions on...behalf"

Table 5.8: Illustrative Extracts for Process Sustainability Questions

Theme	Illustrative Extract Quotes
Knowledge	"I believe we need a much easier way to handle this topic." "In general the environment would not be something that I would consider when choosing an application currently it's too much of an effort."
Communication and Transparency	"A lot of these questions should be directed to software companies and cloud/hosting companies."

Table 5.9: Illustrative Extracts for General Feedback

Answers from the close-ended questions are visualized in Figures 5.1 to 5.9.

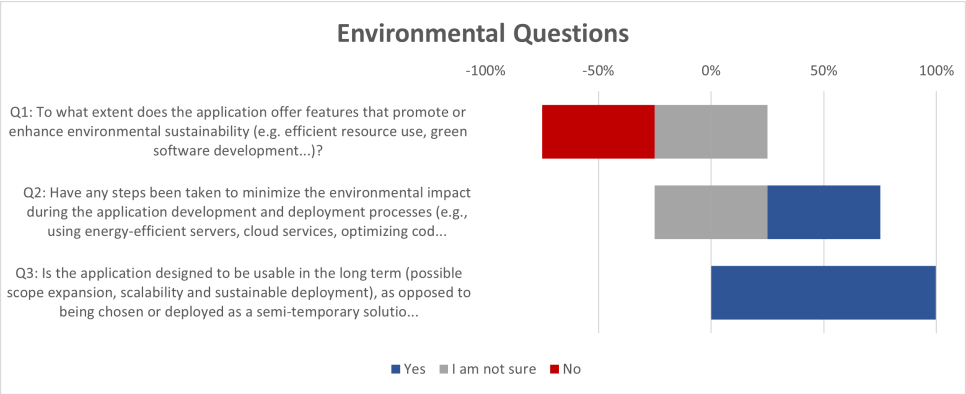


Figure 5.1: Ability to answer environmental sustainability questions regarding their application

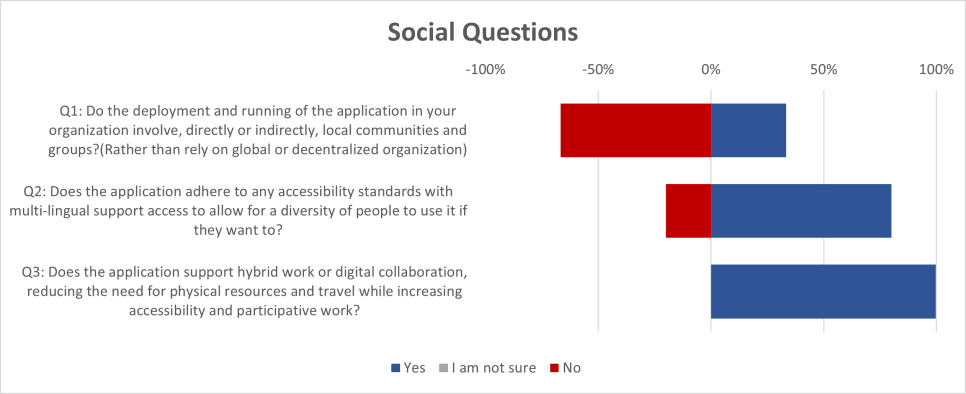


Figure 5.2: Ability to answer social sustainability questions regarding their application

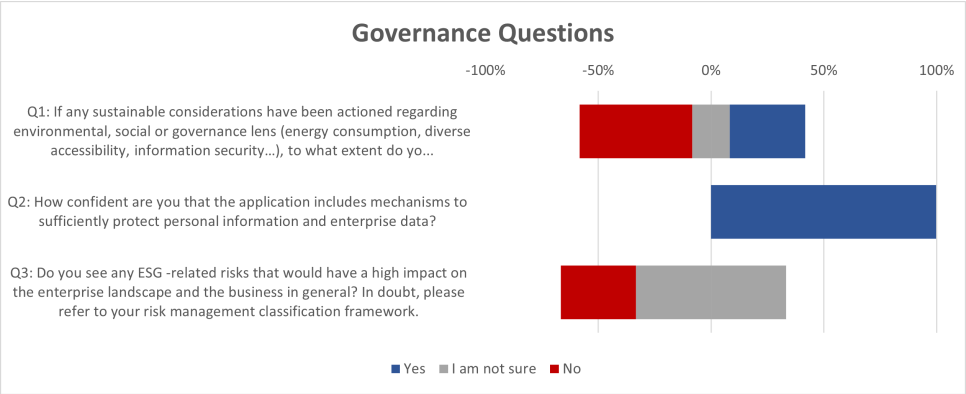


Figure 5.3: Ability to answer governance sustainability questions regarding their application

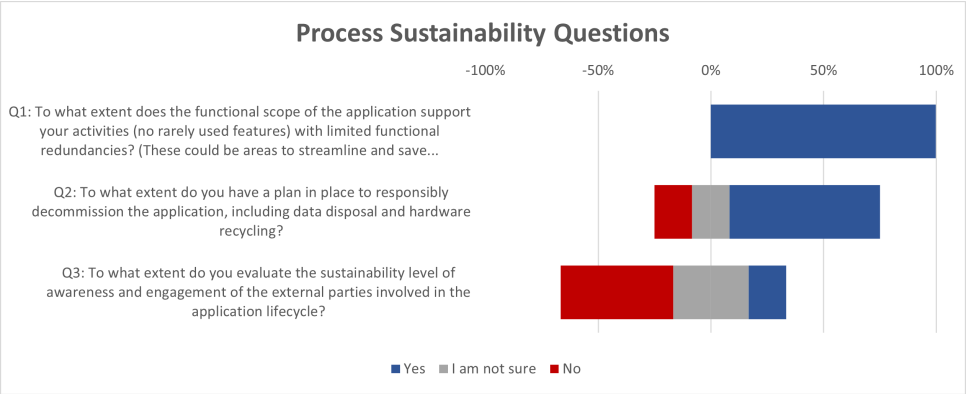


Figure 5.4: Ability to answer process sustainability questions regarding their application

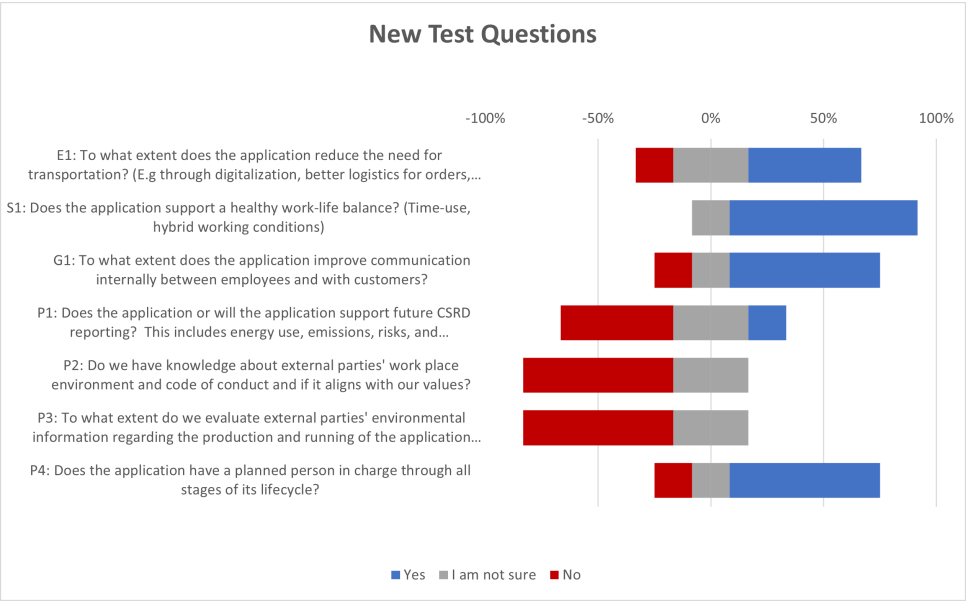


Figure 5.5: Ability to answer the new test questions regarding their application

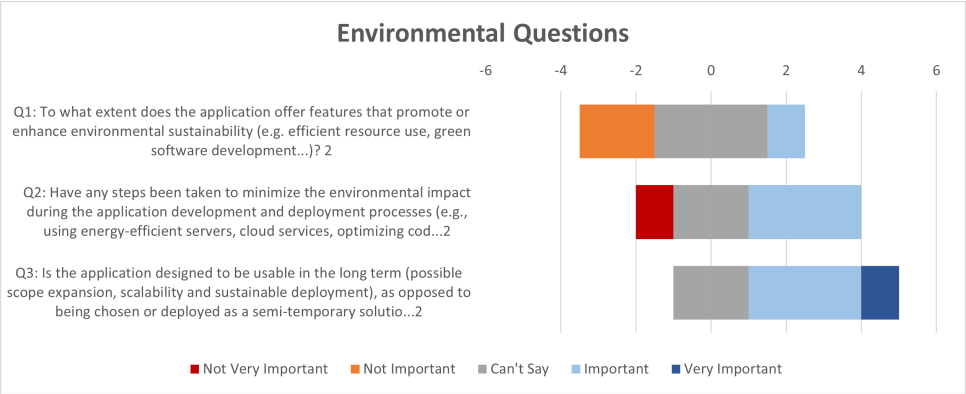


Figure 5.6: Rating how important the environmental sustainability questions are in regards to their application

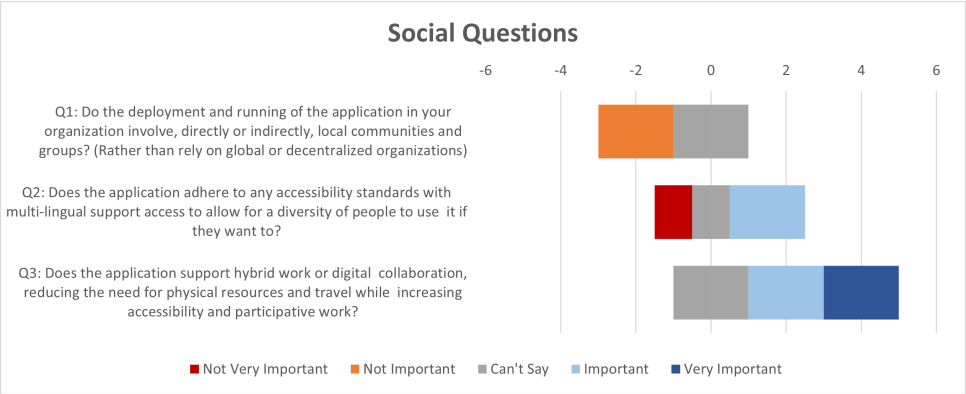


Figure 5.7: Rating how important the social sustainability questions are in regards to their application

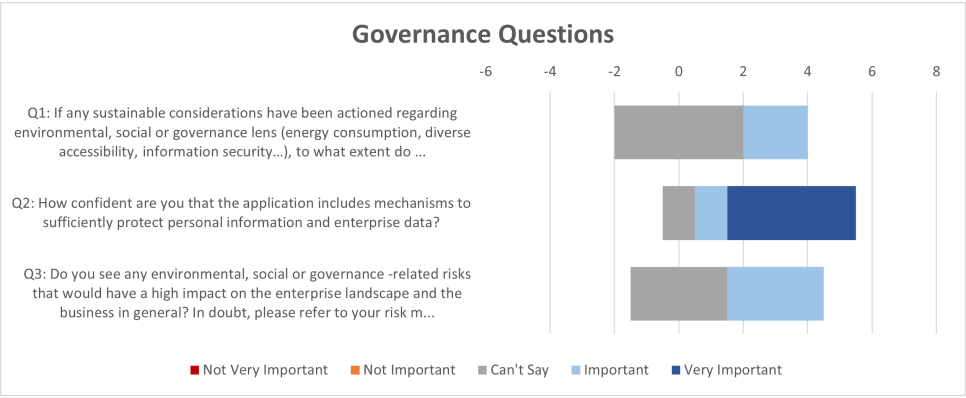


Figure 5.8: Rating how important the governance sustainability questions are in regards to their application

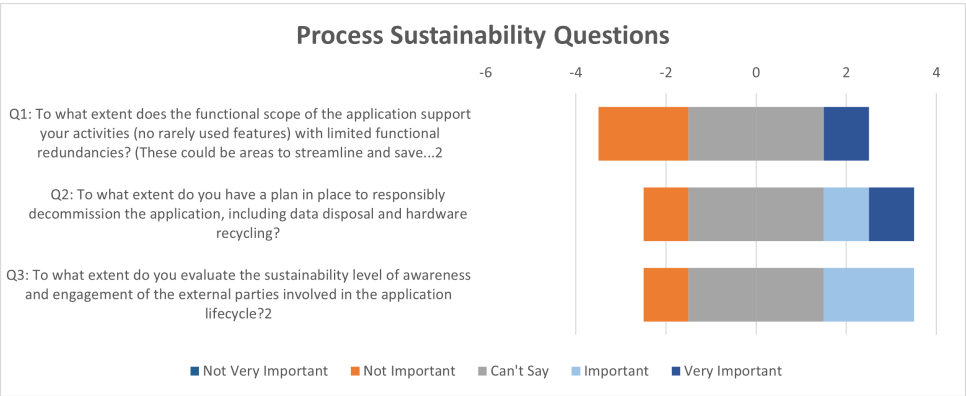


Figure 5.9: Rating how important the process sustainability questions are in regards to their application

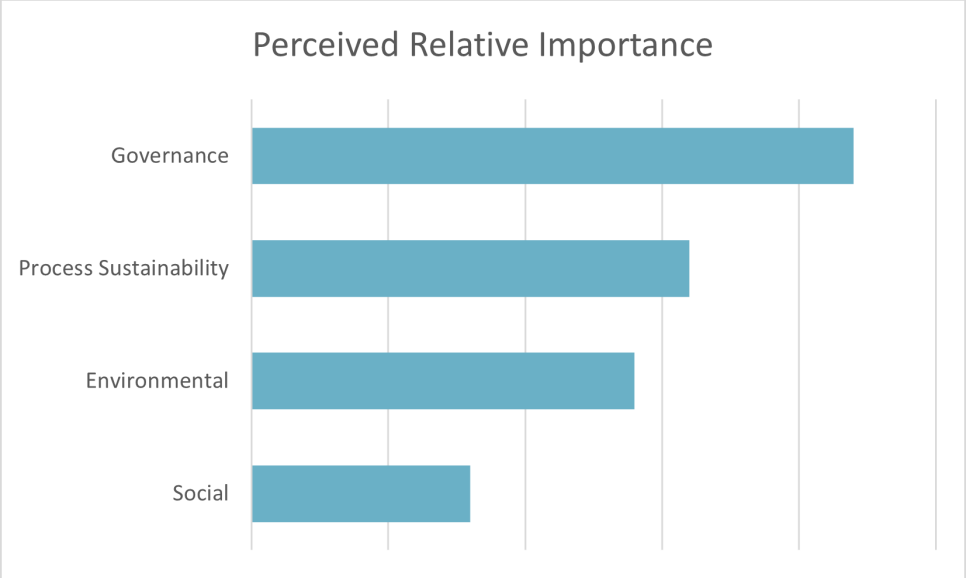


Figure 5.10: Relative importance of each dimension according to service managers

The findings highlight questions that may be hard to answer in their current state as well as questions that may not be considered important from a service manager's point of view. The last insight from the survey was how the service managers would rate each dimension relative to each other which can be seen in Figure 5.10.

5.5.5 Workshop summary

After the workshop was completed, a summary of the findings that would improve the tool could be made. This included highlighting themes that were recurring within the different dimensions, finding questions that are hard to answer in their current state, and getting insight into what the service managers consider important when evaluating their applications. Overall, the majority of questions had a clear consensus among the participants, while some were more split.

The most prevalent themes were a lack of knowledge regarding the subject matter and a lack of information from software vendors. These are also the two issues that would require the most effort to solve from a business point of view since it would include educating employees and changing communication with third-party vendors. Policy and clarification issues are easier to change. The former would require a change in policy regarding how applications are evaluated and used, and the latter would require rephrasing the questions or adding further explanations to difficult questions. The topics that were marked as irrelevant could be looked at if they should be reworded or removed as well.

The qualitative responses could split up the questions into three types: questions that were generally easier to answer, questions that were generally unclear or hard to answer, and questions that did not have a clear consensus. These can be seen summarized in Table 5.10.

Questions that could be answered in their current state	EQ2, EQ3, SQ2, SQ3, GQ2, PSQ1, PSQ2 *Test questions:* S1, G1, P4
Questions that were unclear or hard to answer in their current state	EQ1, SQ1, PSQ3 *Test questions:* P1, P2, P3
Questions that did not have a clear consensus on the ability to answer them	GQ1, GQ3 *Test questions:* E1

Table 5.10: Summary of how ability to answer analysis questions

The original twelve questions were also judged on their importance as perceived by the service managers when evaluating their respective applications. They could be summarized as follows: questions that were regarded as important, questions that were regarded as not important, and questions that were regarded as neither. The questions were grouped by averaging out the results from the Likert scale as seen in the figures and giving double the value to extreme values (e.g "very important"). Any questions with a score of 3 or higher in either direction were deemed as having a consensus and can be seen in Table 5.11

Questions that were regarded as important in evaluation ($\geq$ 3)	EQ3, SQ3, GQ2, GQ3
Questions were not regarded as important in evaluations ($\leq$ -3)	SQ1
Questions that did not have a consensus ($<$ 3 and $>$-3)	EQ1, EQ2, SQ2, GQ1, PSQ1, PSQ2, PSQ3

Table 5.11: Summary of how ability to answer analysis questions

The noticeable takeaways from these summaries are the questions that should be considered to be removed, reworded, or kept as is. Questions that should be removed based on these results are those that were hard to answer and deemed unimportant. The one question that fits this is the first social sustainability (SQ1) question focusing on the inclusion of local groups and communities. This was also seen as a less important question in the interview with Husqvarna's sustainability department. Questions that should be kept in but reworded are questions that are viewed as important but hard to answer. This applied to the third governance question focusing on risk detection. Besides this question, all other important questions could be answered according to the service managers.

The remaining questions that were hard to answer in their current state would have to be evaluated individually whether they should be removed or reworded based on their alignment with previous findings. Since the test questions were added as suggestions and based on previous research, removing them should not be the first option and they should instead be refined further to fit the tool, as they were added for a reason.

The results were also forwarded to Orbus after they had been summarized. When discussing the survey results with them, they were optimistic about using it to improve the tool internally as well, as they found the summarized feedback valuable.

5.6 Implemenatation Plan

The final evaluation and improvement to the model is a summary of changes that should be implemented to properly consider the needs of Husqvarna and the future of sustainable IT within the company.

5.6.1 Dimension and Question Ammendments

Table 5.12 shows how the original 12 questions can be modified to incorporate findings into the assessment tool and to be more representative of Husqvarna's goals. Table 5.13 shows how the new test questions could be incorporated into the tool. As mentioned previously, some questions may need further descriptions or rewordings while some may require larger changes in how communication with vendors takes place and how application management is handled.

Questions	Ammendments
EQ1	Needs to clarify what environmentally sustainable software features mean in the context, such as green software development.
EQ2	For externally developed applications, there is a need for more insight into the development of the application from the vendor regarding server use and code optimization.
EQ3	Generally good question. It may tank overall scores of short-term solutions, but due to their nature, this is not a major concern.
SQ1	Consider removing the question as it is deemed unimportant by multiple stakeholders and difficult to answer.
SQ2	Pivot the question to cover more general accessibility and inclusivity by focusing on features such as text-to-speech or visibility options.
SQ3	Requires rewording or changing since hybrid support is a double-edged question as well as a company policy-related issue. Changing it to ask if it supports work-life balance through, for example, notification control, would help amend this.
GQ1	Needs further explanations to be clearer to the respondent regarding what ESg data collection entails.
GQ2	*No changes needed.*
GQ3	Requires further explanation and educative sessions regarding sustainability-related risks.
PSQ1	*No changes needed.*
PSQ2	*No changes needed.*
PSQ3	Requires more contact with external parties to properly evaluate using this question.

Table 5.12: Amendments for the original 12 questions

Questions	Ammendments
E1	Can be added
S1	Can replace SQ2
G1	Can be added
P1	Would require educative sessions to further explain. Can also be incorporated into GQ1
P2/P3	Requires more contact with external parties to properly evaluate using this question.
P4	Can be added or incorporated into PSQ2

Table 5.13: Amendments to the 7 new questions

Once the feedback had been gathered and processed, the finalized implementation plan could be established with help from EA supervisors. Based on the feedback from the service managers and overall findings, it was decided that the tool would not be implemented during the duration of the project. Instead, an educative session

with multiple departments would take place with the researcher, highlighting the key findings of the project, and the future of the tool. The sessions are aimed at starting a discussion regarding sustainable IT and its future at Husqvarna.

RQ2.2

Research Question 2.2: *What benefits can be gained from evaluating software from a sustainability perspective for companies and society?*
With input from multiple stakeholders, employees, industry reports, and research, the possible benefits of evaluating software from a sustainability perspective have been identified. Firstly, sustainability data reporting is becoming increasingly important within the EU especially. Improving the knowledge regarding the sustainability of software, decision-making, and strategy has the potential to lead to more sustainable applications, which can in turn result in better reporting in the future. This would lead to lower risks and higher stakeholder engagement. Secondly, from a socio-technical standpoint, by focusing on sustainable decision-making, the software used within the company can contribute to healthier work environments and positive environmental effects.
With that said, since there is currently a lack of knowledge in the areas of the current analysis tool (within Husqvarna), the benefits will not be fully realized. Service managers cannot answer a significant number of questions in the tool and there is not sufficient information from application vendors to do a meaningful analysis in the areas that have been highlighted as important throughout the project. Currently, service managers focus more on cost-effectiveness and performance which aligns with industry practices as well. However, by starting the discussion regarding the topic and slowly implementing the tool through workshops and educative sessions, its usefulness will also increase, and benefits may be seen.

6

Discussion

This chapter will discuss the findings of this report, first by going over the results from the previous chapter and their relation to the research questions, then by discussing what these findings mean in the context of existing work. It will also discuss the limitations of the methodology and the findings and how these can be avoided if done again. Lastly, the direction of future research will be highlighted.

6.1 Summary of Key Findings

The findings from the previous chapter highlight some of the current difficulties that currently exist within the tool for Husqvarna, as well as how it should be shaped to better fit the business. It also shows which areas of knowledge are currently underdeveloped at Husqvarna and should in turn be improved for the assessments to be more accurate and useful to future decision-making.

Regarding RQ1, after discussing the development of the tool with Orbus, it did provide an answer to how a tool could be optimized for Husqvarna's purpose. By separating the assessment questions into multiple dimensions of sustainability and subsequently separating each dimension into scaled 1 to 5 questions allows for numerical scoring. This makes it so that applications can be directly compared to others within the same application portfolio when looking at the IT landscape within the business and making future decisions. Furthermore, the assessment can be considered when looking at acquiring new software solutions. The criteria for the assessment is up to each company based on their business and stakeholder goals.

However, this solution does not allow for a standardized system that allows for comparison between different businesses due to the personalized nature of the assessment. Based on related work and previous research, no standardized method has been used to compare applications' sustainability between companies. The assessment can, however, be applied when purchasing new options by referring to the areas when looking at alternative software solutions.

RQ2.1 was covered through the different interviews and background research. Overall, the focus tended to land on environmental and social sustainability. From a historical perspective, these are the two dimensions discussed the most in sustainability reports, and speaking to the sustainability department at Husqvarna, these

were also the two most important dimensions according to them. Interestingly, the service managers rated governance and process sustainability the most important, since these two dimensions are the ones they would normally consider when assessing applications. This is also brought up as part of the "policy" theme where service managers mentioned that company policy may restrict sustainable action in its current state. This could therefore change if a change in prioritization would happen in the future. Furthermore, CSRD was highlighted in multiple findings as an upcoming factor in the assessment. As transparency will increase within the company, making sure that the application portfolio aligns with the new EU requirements is increasingly important, according to Husqvarna.

For RQ2.2, the benefits of implementing the assessment tool were highlighted to be improved reporting and starting to focus more on the socio-technical aspects of the applications within the application portfolio at Husqvarna. The previous research points to there being benefits to this, such as reduced risk and increased stakeholder engagement [20]. However, it is also clear that there is not enough maturity in this regard at Husqvarna to get full use of the current iteration of the assessment tool, as it has not been a focus in the past. Through improved engagement in the EA department, the benefits could prove to be worth the effort.

Overall, the project gained useful insight not only for Husqvarna but also for Orbus, who will use the findings in the future development of the assessment tool. While the original plan of the project was for a full implementation and analysis of the tool, through the interviews and workshop, it was decided that an implementation would not be beneficial in its current state. Therefore, the findings would instead be used to educate different departments and improve the tool for not only Husqvarna but other companies as well.

6.2 Interpretation of Findings

6.2.1 Contextualzing findings within existing literature

All in all, many of the findings at Husqvarna aligned with previous research. More specifically, just like in the industry reports [33], insufficient data regarding ESG areas was one of the main difficulties when it came to being able to fill out the survey. This is an essential aspect of making sure that the sustainability assessments are accurate and useful when measuring the applications.

When it comes to assessments, the current model is designed to measure the sustainable maturity of the applications, much like the SusAF. While part of previous work in this field focused on measuring energy use and environmental impact from a numbers perspective, this would not apply to Husqvarna as this data is currently not tracked for all applications, so a maturity assessment is more fitting, in hopes that it leads to more sustainable decision making. This could, in turn, lead to better data collection and sustainable design in their applications.

As for its relevance to the field of software engineering, the findings highlight common

sustainability oversights in applications and application management. There exists a lack of transparency regarding the sustainability in the development of applications and storing of data. This can require a multi-faceted solution. Developers need to communicate and provide this information to customers, and consumers need to contact and put demands on the developer. Within companies, there also exists a lack of knowledge regarding topics and direction regarding this topic which needs to be communicated in the future.

6.2.2 Implications

6.2.2.1 Theoretical implications

The findings from this project contribute to the theoretical framework of sustainable IT by demonstrating the feasibility as well as the challenges of integrating sustainability assessments into business operations. It highlights the importance of allowing for customizable tools that can cater to organizational needs while contributing to sustainability goals. It also highlights why creating a standardized model for sustainable assessments due to the differences that different companies can have when it comes to sustainability data. Lastly, it provides a possible framework for integrating a numerical sustainable maturity assessment into business practices and the steps that may be necessary to make sure the framework fits the business.

6.2.2.2 Practical Implications

From a practical standpoint, the project has helped shape the tool into a state so that it can be implemented at Husqvarna once they feel that they have reached a point where it can be useful for future operations. It has also started a discussion within the company regarding sustainable practices within IT which has been dismissed in the past to focus on other areas of sustainability. It may therefore be necessary to consider incremental implementation, starting with education and gradual adoption, to build maturity within the department.

The research also contributed directly to the tool developers at Orbus. The practical implication of this is that more businesses than just Husqvarna can also implement the newer model that was improved by Husqvarna's feedback which guides similar companies. Ideally, however, other businesses should also make sure that their sustainability goals are properly represented by the tool.

6.3 Threats to validity

6.3.1 Internal validity

Several factors could potentially threaten the internal validity of this research. First, the customization of the sustainability assessment tool was heavily influenced by input from a limited set of employees within Husqvarna. This narrow focus may have introduced biases, particularly if the selected stakeholders do not represent the

broader perspectives within the organization. Additionally, the tool's evaluation relies on the knowledge of the employees, which, as identified, is currently insufficient regarding sustainable IT. This limitation could result in an inaccurate assessment of the tool's capabilities, thereby skewing the findings. Lastly, the qualitative nature of interviews and workshops, while rich in insights, is subject to subjective interpretations that could affect the study's internal consistency.

One way to improve upon this would simply be to consult more workers at Husqvarna, as well as have a follow-up workshop with improvements to the question. Ideally, this would also take place after educative sessions regarding the topics as this was a point of confusion during the workshop. To address the interpretation of qualitative data, the thematic analysis could also be refined. While the identified themes were forwarded and validated with supervisors, having more input in the coding step would help reduce single-researcher bias. Secondly, since the thematic coding was not presented, and only the themes, the mapping could also be subject to bias.

6.3.1.1 External validity

The nature of the sustainability assessment tool to Husqvarna's specific needs and priorities presents a challenge for external validity. While the tool is designed to be adaptable, its current configuration and the findings derived from it may not directly apply to other organizations with different structures, priorities, or industries. This is specifically applicable to the feedback relayed to Orbus. Moreover, the study's focus on a single company limits the ability to generalize findings across the broader field of IT sustainability in different organizational contexts. The implementation challenges and stakeholder priorities identified at Husqvarna might differ significantly from those in other companies, particularly those operating under different regulatory environments. Furthermore, while Husqvarna wants to focus on assessing a broad range of applications, both internally and externally developed, this may not be true for other organizations. While this project was specifically designed for implementation at Husqvarna, this can be improved by consulting more businesses and external stakeholders.

6.3.2 Construct validity

The scoring system, while intended to provide a nuanced assessment, may not capture the full complexity of each dimension of sustainability. When translating different frameworks (ESG, EU SDGs, SusAF) into the tool, it may simplify the multifaceted nature that each framework provides.

Furthermore, in the case of future implementation, another potential limitation is the reliance on self-reported data from stakeholders, which can be subject to biases such as social bias or misunderstandings of the sustainability concepts being measured, which was highlighted in the workshop. Ensuring that the tool's questions and scoring accurately reflect real-world sustainability impacts requires ongoing validation and refinement, a process that is still in its early stages for this tool.

6.4 Future Research

First of all, future research regarding this project would focus on the full implementation and analysis of the tool in Husqvarna's IT landscape. As it was part of the original plan for the project, finishing it would be the next logical step in the future. Applying the findings from the project, hosting educative sessions with employees, and further iterating on the tool would all be actions that would progress the study further.

Future research in the area of sustainability assessment for software solutions can also be built on the findings of this study and address its limitations to advance the field further. Another promising direction is the development and validation of a more simplified and adaptable sustainability assessment tool. Future work with it could include testing it across diverse industries and organizational contexts to improve generalizability. This would ensure that the tool can properly capture the different areas of sustainability as companies see fit.

Lastly, an area that would improve not only the use of the tool but also the sustainability of the applications improvements would be improved sustainability data. By introducing methods and frameworks for gathering information regarding the sustainability of the different applications through reviews and communication with developers, a more accurate picture of the sustainable maturity of the applications can be created.

7

Conclusion

In summary, this thesis investigated sustainable IT practices through the case study of Husqvarna, aiming to integrate sustainability scores into its application portfolio. The research identified key criteria for defining sustainable IT, determined relevant sustainability dimensions for business evaluation, and assessed the benefits of evaluating software from a sustainability perspective. The findings highlight the importance of incorporating comprehensive sustainability criteria and suggest that a customized approach, tailored to company-specific goals and values, is essential for meaningful sustainability assessments.

Sustainable IT and data were defined, in this case, through a combination of environmental, social, governance, and process sustainability dimensions. The most relevant dimensions include energy and resource use, social and human rights, accountability, and lifecycle management. Evaluating software from a sustainability perspective can enhance decision-making, align with regulatory requirements, improve transparency, and promote responsible resource use.

The current state of sustainability assessments in IT lacks standardization, which can hinder cross-company comparisons. Each organization must prioritize and weigh sustainability aspects according to its specific goals and values. The study revealed a significant gap in knowledge and communication regarding sustainability practices among service managers. This suggests the need for improved training and more transparent vendor communication. Incorporating detailed sustainability criteria and aligning them with regulatory frameworks like the CSRD can enhance the credibility and utility of sustainability assessments.

Future research should focus on developing standardized sustainability assessment frameworks that can be widely adopted across different organizations. Additionally, exploring methods to improve the sustainability knowledge base within companies and enhancing communication channels between vendors and service managers can further advance sustainable IT practices. Longitudinal studies to measure the long-term impact of sustainability integration on business performance and environmental outcomes would also provide valuable insights.

By implementing these findings and recommendations, Husqvarna Group can lead the way in promoting sustainable IT practices, benefiting not only the company but also contributing to broader societal and environmental goals.

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A

Appendix I

Orbus Sustainability Lens Questions (1-5)	
Environmental	To what extent does the application offer features that promote or enhance environmental sustainability (e.g. power-saving modes, efficient resource use, green software development...)?
	Have any steps been taken to minimize the environmental impact during the application development and deployment processes (e.g., using energy-efficient servers, cloud services, optimizing code for performance, etc.)?
	Is the application designed to be usable in the long term (possible scope expansion, scalability and sustainable deployment), as opposed to being chosen or deployed as a semi-temporary solution to be replaced in future?
Process Sustainbility	To what extent does the functional scope of the application support your activities (no rarely used features) with limited functional redundancies? (These could be areas to streamline and save resources)
	To what extent do you have a plan in place to responsibly decommission the application, including data disposal and hardware recycling?
	How do you evaluate the sustainability level of awareness and engagement of the external parties involved in the application lifecycle?
Social	Does the application adhere to any accessibility standards with multi-lingual support access to allow for a diversity of people to use it if they want to?
	Does the application support hybrid work or digital collaboration, reducing the need for physical resources and travel while increasing accessibility and participative work?
	Do the deployment and running of the application in your organization involve, directly or indirectly, local communities and groups, rather than rely on global or decentralized organizations?
Governance	If any sustainable considerations have been actioned regarding environmental, social or governance lens (energy consumption, diverse accessibility, information security…), to what extent do you measure them today, directly or indirectly?
	How confident are you that the application includes mechanisms to sufficiently protect personal information and enterprise data?
	Do you see any environmental, social or governance -related risks that would have a high impact on the enterprise landscape and the business in general? In doubt, please refer to your risk management classification framework.

Figure A.1: Orbus' Sustainability Lens Questions

Sustainability Awareness Framework	
Material and Resources	How are materials consumed to produce the product or service? What about to operate the product or service? E.g.,requires How can it change the way people consume material? E.g., encourage to buy more?
Soil, atmospheric, and water pollution	How can producing parts or supplies generate waste or emissions? How can the use itself produce waste or emissions? How can it influence how much waste or emissions are generated? How can it promote (or impair) recycling?
Biodiversity and land use	How can the system create changes in the composition, size, or use of land? How can it change composition of the soil around it? E.g., occupying / cropland? What about elsewhere?
Energy	How can the product of service affect the need for production of energy? What about the use of energy? E.g. encourages less energy Does the hardware run on renewable energy? Is there a way to incentivise that?
Logistics	How can it affect the need (and distance) for moving people or goods? How can it affect the means by which people or goods move?
Sense of community	How can the product or service affect a person's sense of belonging to these groups?
Trust	How can the product or service change the trust between the users and the business that owns the system?
Inclusiveness and diversity	How can the product or service impact on how people perceive others? What effects can it have on users with different backgrounds, age groups, education levels, or other differences?
Equity	How can the system make people to be treated differently from each other? (think data analytics or decision support)
Participation and communicatio n	How can the product or service change the way people: ○ create networks? ○ participate in group work? ○ support, criticize or argue with others?
Value	How can the system create or destroy monetary value? For whom? Are there any other related types of business value? For whom?
Customer relations management	How can the product or service affect the relationship between the business and its customers? How can it enable co-creation or co-destruction of value? How can it impact the financial situation of their customers & others?
Supply chain	How can the product or service affect the supply chain of the business who owns it? How can these changes in supply chain impact the financial situation? How can it impact the financial situation of their customers & others?
Governance	How can the product or service affect how and by whom such decisions are made? How can the product or service affect the communication channels by which the relationships takes place? How can these changes impact the financial situation of the business and partners?
Innovation, research & development	Do (parts of) the product or service affect the investment on research & development? How can changes in innovation and R&D impact the financial situation? Can it also impact the financial situation of their customers & others?
Maintainability	How are the operating system and runtime environment expected to change what does that required from maintainers of this system? How can the correctness of the system be affected by other systems or affect the correctness of others?
Usability	What kind of knowledge or physical properties are required to use the system and how can this affect different types of users? For example, is good eyesight and small, sensitive hands required to operate a system on a small handheld device?
Adaptability	How could someone want to use the system in another context? What can make that easier/more difficult? What can make that easier/more difficult for the system to adapt itself to fit new usage scenarios?
Security	Which assets controlled by this system would be desirable to an attacker? E.g. financial information, people's whereabouts or preferences, etc. What are the risks associated with these assets? What are other likely vulnerabilities of the system?
Scalability	How can the system support changes in workload? What can make that easier/more difficult?
Health	How can the product or service improve or worsen a person's physical, mental, and/or emotional health? (For example, can it make a person feel anything good or bad - e.g. (under)valued, (dis)respected, (in)dependent, or coerced?)
Lifelong learning	How can the product or service affect people's competencies?
Privacy	How can the product or service expose (or help to hide) a person's identity, whereabouts or relations?
Safety	How can the product or service expose (or protect) a person from physical harm? How can it make a person feel more (or less) exposed to harm? What if used in an unintended way?
Self-awareness and Free will	How can the product or service empower (or prevent) a person from taking an action / decision when necessary? Can those affected by the product or service understand its implications, express concerns or be represented by someone?

Figure A.2: Sustainability Awareness Framework Questions

B

Appendix II

Husqvarna Sustainability Analytics

This survey is aimed to evaluate the questions that will be used in a sustainability analysis tool within the OrbusInfinity system. Each question does not need to be answered, instead the questions themselves will be evaluated.

For each question from the Sustainability Tool, provide feedback on the content and formulation of the question in regard to the application(s) for which you are responsible.

* This form will record your name, please fill your name.

Introduction

1. What applications(systems) are you responsible for?

Environmental Considerations

These questions aim to evaluate how the applications can have an impact on the environment.

2. Do you have sufficient knowledge about this application to confidently answer this question?

	Yes	No	I am not sure
Q1: To what extent does the application offer features that promote or enhance environmental sustainability (e.g. efficient resource use, green software development...) ?	◯	◯	◯
Q2: Have any steps been taken to minimize the environmental impact during the application development and deployment processes (e.g., using energy-efficient servers, cloud services, optimizing code for performance, etc.)?	◯	◯	◯
Q3: Is the application designed to be usable in the long term (possible scope expansion, scalability and sustainable deployment), as opposed to being chosen or deployed as a semi-temporary solution to be replaced in future?	◯	◯	◯

3. Do you feel that any of the questions should be reworded or restructured? If so, how?

4. How important would you consider the questions when evaluating applications from an environmental sustainability perspective?

	Not very important	Not important	Can't say	Important	Very Important
Q1: To what extent does the application offer features that promote or enhance environmental sustainability (e.g. efficient resource use, green software development...) ?	◯	◯	◯	◯	◯
Q2: Have any steps been taken to minimize the environmental impact during the application development and deployment processes (e.g., using energy-efficient servers, cloud services, optimizing code for performance, etc.)?	◯	◯	◯	◯	◯
Q3: Is the application designed to be usable in the long term (possible scope expansion, scalability and sustainable deployment), as opposed to being chosen or deployed as a semi-temporary solution to be replaced in future?	◯	◯	◯	◯	◯

Social Sustainability Considerations

These questions aim to evaluate how the applications can affect people who use it.

5. Do you have sufficient knowledge about this application to confidently answer this question?

	Yes	No	I am not sure
Q1: Do the deployment and running of the application in your organization involve, directly or indirectly, local communities and groups? (Rather than rely on global or decentralized organization)	◯	◯	◯
Q2: Does the application adhere to any accessibility standards with multi-lingual support access to allow for a diversity of people to use it if they want to?	◯	◯	◯
Q3: Does the application support hybrid work or digital collaboration, reducing the need for physical resources and travel while increasing accessibility and participative work?	◯	◯	◯

6. Do you feel that any of the questions should be reworded or restructured? If so, how?

7. How important would you consider the questions when evaluating applications from a social sustainability perspective?

	Not very important	Not important	Can't say	Important	Very Important
Q1: Do the deployment and running of the application in your organization involve, directly or indirectly, local communities and groups? (Rather than rely on global or decentralized organizations)	◯	◯	◯	◯	◯
Q2: Does the application adhere to any accessibility standards with multi-lingual support access to allow for a diversity of people to use it if they want to?	◯	◯	◯	◯	◯
Q3: Does the application support hybrid work or digital collaboration, reducing the need for physical resources and travel while increasing accessibility and participative work?	◯	◯	◯	◯	◯

Governance Consideration

These questions aim to evaluate how the applications can affect the company.

8. Do you have sufficient knowledge about this application to confidently answer this question?

	Yes	No	I am not sure
Q1: If any sustainable considerations have been actioned regarding environmental, social or governance lens (energy consumption, diverse accessibility, information security...), to what extent do you measure them today, directly or indirectly?	◯	◯	◯
Q2: How confident are you that the application includes mechanisms to sufficiently protect personal information and enterprise data?	◯	◯	◯
Q3: Do you see any ESG - related risks that would have a high impact on the enterprise landscape and the business in general? In doubt, please refer to your risk management classification framework.	◯	◯	◯

9. Do you feel that any of the questions should be reworded or restructured? If so, how?

10. How important would you consider the questions when evaluating applications from a governance sustainability perspective?

	Not very important	Not important	Can't say	Important	Very Important
Q1: If any sustainable considerations have been actioned regarding environmental, social or governance lens (energy consumption, diverse accessibility, information security...), to what extent do you measure them today, directly or indirectly?	◯	◯	◯	◯	◯
Q2: How confident are you that the application includes mechanisms to sufficiently protect personal information and enterprise data?	◯	◯	◯	◯	◯
Q3: Do you see any environmental, social or governance - related risks that would have a high impact on the enterprise landscape and the business in general? In doubt, please refer to your risk management classification framework.	◯	◯	◯	◯	◯

Process Sustainability Consideration

These questions aim to evaluate the overall application lifecycle, including 3rd party effects.

11. Do you have sufficient knowledge about this application to confidently answer this question?

	Yes	No	I am not sure
Q1: To what extent does the functional scope of the application support your activities (no rarely used features) with limited functional redundancies? (These could be areas to streamline and save resources)	◯	◯	◯
Q2: To what extent do you have a plan in place to responsibly decommission the application, including data disposal and hardware recycling?	◯	◯	◯
Q3: To what extent do you evaluate the sustainability level of awareness and engagement of the external parties involved in the application lifecycle?	◯	◯	◯

12. Do you feel that any of the questions should be reworded or restructured? If so, how?

13. How important would you consider the questions when evaluating applications from a process sustainability perspective?

	Not very important	Not important	Can't say	Important	Very Important
Q1: To what extent does the functional scope of the application support your activities (no rarely used features) with limited functional redundancies? (These could be areas to streamline and save resources)	◯	◯	◯	◯	◯
Q2: To what extent do you have a plan in place to responsibly decommission the application, including data disposal and hardware recycling?	◯	◯	◯	◯	◯
Q3: To what extent do you evaluate the sustainability level of awareness and engagement of the external parties involved in the application lifecycle?	◯	◯	◯	◯	◯

Test questions

These questions highlight areas that may be missing from the current version of the sustainability tool based on research and interviews with other employees at Husqvarna.

14. Do you have sufficient knowledge about this application to confidently answer this question?

	Yes	No	I am not sure
E1: To what extent does the application reduce the need for transportation? (E.g through digitalization, better logistics for orders, etc.)	◯	◯	◯
S1: Does the application support a healthy work-life balance? (Time-use, hybrid working conditions)	◯	◯	◯
G1: To what extent does the application improve communication internally between employees and with customers?	◯	◯	◯
P1: Does the application or will the application support future CSRD reporting? This includes energy use, emissions, risks, and opportunities of the application.	◯	◯	◯
P2: Do we have knowledge about external parties' work place environment and code of conduct and if it aligns with our values?	◯	◯	◯
P3: To what extent do we evaluate external parties' environmental information regarding the production and running of the application and servers?	◯	◯	◯
P4: Does the application have a planned person in charge through all stages of its lifecycle?	◯	◯	◯

Overall Feedback

15. Are there any questions/areas you feel are missing currently? (This includes areas which you would normally consider when choosing between two software applications)

16. Are there any areas you feel should be less represented? (Consider questions or areas which you normally would not consider when evaluating applications and areas where there is a lack of knowledge)

17. How would you rank the different areas in terms of importance for your application?

- Environmental
- Social
- Governance
- Process Sustainability