Towards Incorporating Sustainability while Taking Software Product Management Decisions

Birgit Penzenstadler¹, Mahvish Khurum², and Kai Petersen²

¹ Technische Universität München, Germany
penzenst@in.tum.de
² Blekinge Institute of Technology, Sweden
{Mahvish.Khurum|Kai.Petersen}@bth.se

Abstract. Software product managers are missing guidelines on how to incorporate different dimensions of sustainability in software product management and requirements selection decision-making. This is a challenge because considering sustainability perspective while selecting requirements has become a major objective for software product development companies; however, it is unclear how to support it during complex product management decision-making. In this paper, we identify the value aspects related to sustainability for software requirements selection. An exemplary dialogue between a consultant and a product manager illustrates how the proposed approach can be used while taking product management and requirements selection decisions. Our contribution provides software product managers with guidance on how to incorporate value aspects related to sustainability while taking software product management and requirements selection decisions.

Keywords: Sustainability, value-based software engineering, decision-making, software product management

1 Introduction

In today’s world, software has become the main competitive advantage, enabling faster and cheaper innovation as well as product differentiation, and at the same time hardware is becoming standardized [10,35]. Simultaneously, the size and complexity of software in products are increasing, and so is the impact of software development decisions on the overall product offering [15]. That is, any decision taken regarding software, e.g. what features to realize, what quality to offer, or what technology to choose, will impact the entire product’s life cycle and value, not to mention that it limits future possibilities and direction of the product and business (economic sustainability) [119]. Along with this, due to increased awareness about environmental, social and human sustainability, a challenging question is how a company can build innovative products that not only meet the needs of its customers, but are also built in a socially responsible and sustainable way? While it is required to build special software for the
customers to measure, monitor and act on various sustainability indices, it is equally important that the products are developed and managed in an adequate way with an in-depth understanding of the environment they are applied in. This situation gives rise to many decision-making challenges for industry practitioners, for example, which value aspects with respect to sustainability need to be considered while taking software management decisions? How does the realization of one functional or quality feature influence the sustainability value of the product offering, where short-term potential sales and revenues are almost always premiered over sustainability aspects? Answering these questions can help to innovate and develop products that do not only deliver value to the customers, but also enable development of products keeping in view the sustainability perspective. This perspective spans all levels of decision making: on the project, the product, and the portfolio level. Our research question is: How can we incorporate sustainability as a primary objective with the conventional goals in software product management decisions?

Value-based software engineering (VBSE) can help answering these questions as it emphasizes that every decision and/or feature of a product does not have an equal value like in a value-neutral setting [2]. This requires making decisions that are better for overall value creation, according to Kontio et al. [21] and Rönkkö et al. [29], and balancing short-term and long-term value creation.

**Contribution** The primary contribution of this paper is a list of value aspects that need to be considered from the perspective of sustainability while taking product management and development decisions. The Software Value Map is used as the basis for identification of these value aspects. The Software Value Map [20] provides a consolidated view on value aspects relevant for taking software product management and development decisions based on the Balanced Score Card approach. In addition to its application for sustainability concerns, a set of value aspects not yet covered by the Software Value Map has also been included, where each aspect is described and given a rationale. The identified value aspects can be used as criteria for taking requirements selection decisions. The application of the approach is illustrated in a fictitious dialogue between a product manager and a consultant.

### 2 Foundations and Related Work

The following sub-sections give a brief introduction to the concepts of sustainability and the Software Value Map as well as an overview of related work.

**What is Sustainability?** The four main dimensions of sustainability that we consider important are human, social, economic, and environmental, see Goodland [3]. The three latter ones are the dimensions known from the most cited definition of sustainable development by Brundtland et al. [3]: “...meets the needs of the present without compromising the ability of future generations to satisfy their own needs.” The first dimension, human, is not present in the public discussion, but we argue that it should be included because it is the basis for the others.
**Human sustainability:** Human sustainability refers to the maintenance of the private good of individual human capital. The health, education, skills, knowledge, leadership and access to services constitute human capital. [9]

**Social sustainability:** Social sustainability means maintaining social capital and preserving the societal communities in their solidarity. Social capital is investments and services that create the basic framework for society. [9]

**Economic sustainability:** Economic capital should be maintained. The definition of income as the amount one can consume during a period and still be as well off at the end of the period can define economic sustainability, as it devolves on consuming value-added (interest), rather than capital. [9]

**Environmental sustainability:** Although environmental sustainability is needed by humans, it itself seeks to improve human welfare by protecting natural resources. These are water, land, air, minerals and ecosystem services; hence much is converted to manufactured or economic capital. Environment includes the sources of raw materials used for human needs, and ensuring that sink capacities recycling human wastes are not exceeded. [9]

Our analysis of how to incorporate sustainability into software product management decisions is based on these definitions as our understanding of sustainability. The foundation we use for guidance in taking software product management decisions is the Software Value Map, described in the following section.

**The Software Value Map.** The Software Value Map [20] provides a consolidated view of the software value concept utilizing four major perspectives: the financial, the customer, the internal business process, and the innovation and learning. The value aspects and value components contained in the map are collected through extensive review of economics, management and value-based software engineering literature.

The value map offers a unified view of value, which can be used by professionals to develop a common understanding of value, as well as acting as decision support to assure no value perspective is unintentionally overlooked when taking product management decisions. For example, during requirements selection in addition to short term increases in customer value and company revenue, a company’s and product’s long-term sustainability view can also be considered. While evaluating the effects of a requirement on the maintainability value of the product’s architecture, human capital value of the company and innovation value would enable a comprehensive (long-term) impact analysis of a certain decision. Thus, by having a value focus, the overall trade-off between positive and negative impact on the present product offering can be estimated. This is central from many perspectives. For example, from a business perspective, the selection and realization of a feature might be good idea, but simultaneously the long-term effects pertaining to, e.g., sustainability of system architecture, might be very negative.

The taxonomy used to categorize the perspectives for measuring value was inspired by the balanced scorecard (BSC) approach, see Kaplan et al. [16,17]. BSC can be defined as a set of measures that gives managers a fast but comprehensive view of the business using four main perspectives, namely the financial,
customer, internal business process, and innovation and learning [16,17], each described below.

The financial perspective contains aspects that address the company’s implementation and execution of its strategy which are contributing to the bottom-line improvement of the company. It represents the long-term strategic objectives of the organization and thus incorporates the tangible outcomes of the strategy in traditional financial terms [32,29]. Some of the most common financial measures that are incorporated in the financial perspective are earned value analysis and profit margins.

The customer perspective defines the value proposition that the company will apply to satisfy customers and thus generate more sales to the most desired (i.e. the most profitable) customer groups, see, e.g., Steven [32]. Measures that are selected for the customer perspective should measure both the value that is delivered to the customer (value proposition) with respect to the perceived value, which may involve time, quality, performance and service, and cost, and the outcomes that come as a result of this value proposition (e.g., customer satisfaction and market share).

The internal process perspective is concerned with the processes that create and deliver the customer value proposition. It focuses on all the activities and key processes required in order for the company to excel at providing the value expected by the customers both productively and efficiently. Quality, cycle time, productivity and cost are some aspects where performance value can be measured [16].

The innovation and learning perspective is the basis of any strategy and focuses on the intangible assets of an organization, mainly on the internal skills and capabilities. The innovation and learning perspective is the intellectual capital categorized as human capital, structural capital, and the organization capital of a company [16,23].

Related Work. The ISPMA provides a first body of knowledge, which does not explicitly consider sustainability yet [15]. Penzenstadler et al. [27] conducted a systematic literature review on sustainability in software engineering. The review revealed no work specifically related to sustainability in the context of software product management decision making. Cabot et al. [7] performed a case study for sustainability as goal for the ICSE organization with i* goal models to support decision making for future conference chairs, but don’t discuss decision support for potential measures and do not provide methodical guidance or decision support. Naumann et al. [26] investigate how web pages can be developed with little environmental impact, i.e., energy-efficiently, but do not discuss implications on product management. Mahaux et al. [24] performed a case study on a business information system for an event management agency that advertises environment-friendly events but do not address the decision making challenge. While all of these works refer to sustainability goals, none of them discusses values related to sustainability and how to consider them while taking product management and requirements selection decisions. Moreover, within research on value-based software engineering, to the best of our knowledge, no
work yet explicitly discusses sustainability as one of the major consideration in software product management decision-making.

3 Identification of Value Aspects for Sustainability

The software value map can be used as a basis for identification of value aspects to be considered from different sustainability perspectives, while taking product management and requirements selection decisions. We discuss four sustainability dimensions and value aspects relevant to each of them. The dimensions are given with the rationale for their relevance to the discussed sustainability dimension along with the references for further readings. Tables list the values (column Value Name) related to the sustainability dimensions, identify the balanced scorecard perspective they belong to (column Perspective), describe the value itself (column Value Description), why it matters for sustainability (column Rationale), and what can be done in order to improve it with references to further reading (column Actions & Further Reading). Please note that the list of identified value aspects is not complete rather it is the first attempt towards theoretical foundations for incorporating sustainability perspective while taking requirements selection decisions.

**Human Sustainability.** Software is developed and managed by people. Therefore, it is fundamental to consider value aspects related to human capital while taking product management decisions. The human capital value is described in Table 1. Although value aspects related to human sustainability are not necessarily related to all product management decisions, they actually influence the effects of other value aspects related to sustainability. For example, satisfied developers will be more focused to build high quality products with efficient use of resources.

<table>
<thead>
<tr>
<th>Value Name</th>
<th>Perspective</th>
<th>Value Description</th>
<th>Rationale</th>
<th>Actions &amp; Further Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human capital value</td>
<td>Innovation and learning</td>
<td>Human capital value refers to the stock of skills and knowledge embodied in the ability to perform labor so as to produce economic value. It is the value of skills and knowledge gained by a worker through experience.</td>
<td>For human sustainability, human capital value should be increased by enhancing the skills and knowledge of the developers since they are the work force that develops the system.</td>
<td>Offering training and continued education improves skills and knowledge of an employee. Fitz-enz provides measures for the economic value of employee performance.</td>
</tr>
</tbody>
</table>

**Social Sustainability.** For supporting social sustainability, a software development company may want to consider customer capital value while taking product management decisions. Furthermore, network externalities play a role in binding the customer. In addition to the values in Table 2 that are identified from the Software Value Map, there are other values that can be discussed in this context. The reason for not listing them is that they are related less directly to the software product under development, rather to the surrounding environment,
Table 2. Value aspects for social sustainability

<table>
<thead>
<tr>
<th>Value Name</th>
<th>Perspective</th>
<th>Value Description</th>
<th>Rationale</th>
<th>Actions &amp; Further Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer capital value</td>
<td>Internal Business perspective</td>
<td>Value of relationships that a firm builds with its customers, and which is reflected in their loyalty to the firm and/or its products. It is not reflected in a balance sheet in monetary terms.</td>
<td>Loyalty of customers is a stable basis for continuous bonding and customer retention [14].</td>
<td>Hennig-Thurau et al. [14] suggests improving bonding with customer with the use of motivation theory. Storbacka et al. [33] links service quality with customer satisfaction and profitability.</td>
</tr>
<tr>
<td>Network externalities</td>
<td>Customer perspective</td>
<td>The amount of other users of the software product that are relevant to the focal user, e.g., who might be motivated to use a service due to incentives for the user</td>
<td>If there are incentives for a user to motivate other people to use a service, the user might keep using it for two reasons: the incentive (e.g., lower costs), and the network of users that share the service [15].</td>
<td>Katz et al. [18] provide an analysis of the options to improve availability of complementary goods and services.</td>
</tr>
</tbody>
</table>

for example, values related to labor practices, human rights, society, and ethical behavior (see Silvius and Schipper [31]). Activities for good labor practices are to ensure employment, to work on labor-management relations, to provide training and education as well as organizational learning, and to offer diversity and equal opportunity. Human rights support is, e.g., to prevent discrimination. For society, potential measures are to improve community support, to perform adequate market communication, and to guard customer privacy [31]. Ethical behavior includes checking investment and procurement practices [31].

**Economic Sustainability** Within a software development context, value aspects related to economic sustainability need to be considered while taking product management decisions. The values detailed in Table 3 are maintainability value, innovation value, differential value, and physical value w.r.t cost. Economic sustainability is the aspect that is already most present in today’s software business. One sub aspect of this is software sustainability, a term used interchangeably with software maintenance, and an innovation infrastructure are fundamental inputs to continuously maintain and evolve software products such that they sustain economically throughout their entire planned lifecycle. Moreover, competitive advantage has to be maintained to ensure economic sustainability of the company.

**Environmental Sustainability** Environmental sustainability may be improved by improving the market requirements value, the physical value w.r.t. cost, the sustainability value of technology, and the product’s intrinsic value. Each of the values is detailed in Table 4. Selling software as services enables a higher rate of innovation and also reduces the number of expensive hardware upgrades that needs to be done. This, in turn, means an increased environmental sustainability. While it can go hand in hand with economic efficiency, this can also have cost-increasing effects, e.g., through additional activities.

**Interrelationships** Interrelationships in the value aspects identified from different sustainability dimensions are possible. The interrelationships can exist as the following effects:
Table 3. Value aspects for economic sustainability

<table>
<thead>
<tr>
<th>Value Name</th>
<th>Perspective</th>
<th>Value Description</th>
<th>Rationale</th>
<th>Actions &amp; Further Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintainability value</td>
<td>Internal business perspective</td>
<td>The capability of the software product to be modified. Modifications include improvements or adaptation of the software to changes in environment, and in requirements and specifications.</td>
<td>Maintainability of a software product is a foundation for sustainability [30] in a broader understanding, as evolution balances the factors to be accounted for when aiming at sustainability.</td>
<td>An approach for achieving software sustainability and how to measure it is given by Seacord [30].</td>
</tr>
<tr>
<td>Innovation value</td>
<td>Innovation and learning</td>
<td>The practical value of subject technology that is materialized in market (as a product or service) or in business process (as process innovation)</td>
<td>According to Hansen et al. [13], sustainability is a key driver of innovation. If they go hand in hand, innovation has to be supported.</td>
<td>Hansen et al.’s framework [13] allows also for conclusions with respect to the market.</td>
</tr>
<tr>
<td>Differential value</td>
<td>Internal business perspective</td>
<td>Differentiation is the process of distinguishing the differences of a product or offering from others, to make it more attractive to a particular target market. This involves differentiating it from competitors’ products as well as one’s own product offerings.</td>
<td>In order to have sustainable competitive advantage, it is fundamental to strive product features/capabilities that enable economies of development and/or lower profit margins (see Lado et al. [22]).</td>
<td>Hall [11] gives a framework for linking capabilities to sustainable competitive advantage.</td>
</tr>
<tr>
<td>Physical value w.r.t. cost (PVc)</td>
<td>Internal business perspective</td>
<td>A product being developed and marketed with lower development cost will have higher Physical value w.r.t. to cost.</td>
<td>For economic sustainability, it is fundamental to keep the development costs as low as possible [9].</td>
<td>Byggeth [6] proposes a procedure for sustainability-driven design optimization illustrated with a case study.</td>
</tr>
</tbody>
</table>

- A positive impact on one value aspect might have positive impact on one or more sustainability dimension
- A negative impact on one value aspect might have negative impact on one or more sustainability dimension
- A positive impact on one value aspect might have a negative impact on one or more sustainability dimension and vice versa

For example, if quality features, not even demanded by the customers, are provided; the intrinsic value of the product might be very high, however, this will negatively impact the environmental sustainability perspective as Physical value w.r.t. cost would decrease due to extra features produced (a waste). On the other hand, if generic products (which are demanded by majority of the customers) are developed and sold, Market requirements value would be high and Physical value w.r.t. cost would be high which doubles the positive impact on the environmental sustainability. Moreover, by developing maintainable products, while Maintainability value is increased which positively impacts the economic sustainability; however, this could have a negative impact on Human capital value because the developers feel that by maintaining the existing code no new skills are being learnt. Consequently, human sustainability is negatively impacted. Resolving trade-offs between conflicting dimensions (often between economic and environmental, as environmentally sustainable involves adequate supplies) can only be solved by goal prioritisation—the economic side or the environment.
Table 4. Value aspects for environmental sustainability

<table>
<thead>
<tr>
<th>Value Name</th>
<th>Perspective</th>
<th>Value Description</th>
<th>Rationale</th>
<th>Actions &amp; Further Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market requirements value</td>
<td>Internal business perspective</td>
<td>Represents the production value with respect to a given market requirement (Time &amp; effort to implement a feature vs requirement’s market demand &amp; value)</td>
<td>Producing generic products can save resources (such as computers, electricity), as customized solutions may require additional environmental resources [12]. Murugesan [25] proposes principles and practices for green IT.</td>
<td></td>
</tr>
<tr>
<td>Physical value w.r.t. cost (PVc)</td>
<td>Internal business perspective</td>
<td>Represents the production value w.r.t. cost. A product being developed and marketed with lower development cost will have higher PVC</td>
<td>From environmental sustainability perspective, it should be ensured the resources are not wasted (adding to cost) during product development. However, efficiency can only contribute to, but not achieve sustainability by itself, see, e.g., Tomlinson et al. [34]. Silvius [31] takes transport, energy, waste, and materials into the resource balance. Poppendieck [25] proposes to eliminate “waste” in terms of partially done work, relearning, task switching, delays, defects etc.</td>
<td></td>
</tr>
<tr>
<td>Sustainability value of technology</td>
<td>Innovation and learning</td>
<td>The sustainability value of technology means how good or bad a technology is rated with respect to environmental impact due to its own production as well as usage during lifetime and later on for disposal.</td>
<td>If a new technology is being implemented, what is the environmental sustainability value of technology? Can it, e.g., increase interoperability possibilities to design more generic products/solutions? Brown [3] provides insights and rationale to evaluate sustainability in technology for environmentally sound innovation.</td>
<td></td>
</tr>
<tr>
<td>Product intrinsic value</td>
<td>Customer perspective</td>
<td>This includes functionality and quality attributes e.g. usability, reliability etc., of the product.</td>
<td>From environmental sustainability perspective, features and quality provided in the product has to be balanced w.r.t. resources used. Byggeth [5] proposes a set of guiding questions for sustainable product development.</td>
<td></td>
</tr>
</tbody>
</table>

4 Illustrative Usage Scenario

The following dialogue is a fictitious discussion between Daniel and Mick. It illustrates the first steps of a usage scenario for a sustainability-driven application as depicted in Fig. 1. Mick is a product manager in a big car manufacturing company that wants to develop a car-sharing platform. Daniel is a method consultant from a well-established IT consulting company. They have already worked together in the past and generally get along well. The rich picture in Fig. 2 shows the most important elements of the car sharing platform. There is a community of users who can rent and share cars, there is a backend data base and there is a business infrastructure with maintenance, administration, and management. The speech bubbles indicate first starting points for the different aspects of sustainability. They first name the sustainability aspect and then, in parentheses, an exemplary respective value that can be considered for the car sharing platform.

**Sustainability as Objective** “The vice-president tells me that we need to focus on sustainability for the development project of that new platform—so, how do I do that?” Mick opens the discussion. “Well, that depends on the goals you want to achieve with respect to sustainability.” Daniel is a consultant well trained in first analyzing the problem and then developing a solution step by step with his customers, Fig. 1 Step 1. Mick sighs internally: “That’s not much
Daniel is not surprised about this statement and provides a starting point: “Okay, I do agree that many people might have a different understanding of what sustainability is, but luckily there are concrete definitions out there that we can use to make the concept more tangible in your context, for example the one given by Robert Goodland ...” and he quickly sketches the four dimensions of sustainability (given in Sec. 2): HUMAN, SOCIAL, ECONOMIC, and ENVIRONMENTAL, Fig. 1. Step 2.

“I see ...” Mick acknowledges that it might be more than an abstract concept. Daniel takes that as an offer to further guide his customer: “Sure, that is still quite abstract, but it is the most general goal you can start with for that particular dimension of sustainability. From here on, we can refine the goal like any abstract business goal your vice-president might come up with.” Mick is still skeptical: “I’m curious how you want to turn that into goals applicable to software-intensive systems development, but go ahead, we’ll give it a try.”

Daniel jumps up again to make more sketches on the whiteboard: “We can look
at that from the four different dimensions of sustainability.” He starts questioning: “What are current issues that need improvement? What are the values that are important here? What do your users want?” Mick is a little surprised by that question: “I guess they would want a good car sharing solution.” “That’s a start. However, think about what values lie behind the need for a car sharing solution, for example, the wish to save the costs for a car and the wish to do something for the environment by saving energy?” “Good point”, says Mick, “How can I structure my thoughts when trying to tackle the sustainability aspects for my product decisions and requirements elicitation?”

“I have that Software Value Map that gives a consolidated overview of common values for software-intensive product development. I have used it with a number of customers and it has proven sufficiently encompassing to be particularly helpful during analysis.” And he hands him a one-page introduction to the SVM as provided in Sec. 2. Mick scans it quickly but then returns to the discussion at hand: “Such a map is definitely useful for a start, but I need applicable guidance.”

**Human Sustainability** “Let’s first take a look at the human sustainability dimension”, Daniel continues (Fig. 1 Step 3), “According to the value map, the most important value that is relevant to be considered for human sustainability is HUMAN CAPITAL VALUE. Some of the metrics we can use to measure human capital are the general satisfaction of people and their impression of how their skills and knowledge develop over time. That would preserve human capital and therefore support human sustainability. So, how can we improve these two?”

“Okay, I see. Let me think”, Mick picks up the thought, “User satisfaction depends on various factors, for example, the service costs and a good feeling when using the service. That’s an issue for both our interface designers, who optimize the user interaction with the system and its services, and our economics guys, who calculate the service prices.” “And service level agreements like a high availability of cars et cetera.” Daniel adds.

“Sure, and if we want to support the improvement of their set of skills and knowledge, we could offer, for example, an education program at the time of registration. Could that be a start?” Mick asks. “Of course!” Daniel replies, “Most of your users will be aware of the basics but you can still provide them with more information on the specifics of your service and the impact on the environment.”

“Continuing that line of thought with knowledge and transparency,” Mick extends the idea, “we can perform an online evaluation of statistics and how much energy was saved in total, plus questionnaires that track even more, for example, which other means of transport they use apart from car sharing, and every user can optionally take part in that and gain knowledge on their individual statistics.” “...and, thereby, offer to provide them with additional information, yes, good idea.” Daniel agrees.

Mick starts taking notes on his To-Do template and scribbles facts here and there frowning at the piece of paper that is turning quite illegible. Daniel watches for a while and then proposes: “We have developed a template for this purpose that we call Impact Evaluation Pattern—maybe you would like to make use of it?” “Does that cost me extra?” grumbles Mick. “No”, shrugs Daniel, “it’s part of
“Simply put the concept of Impact evaluation patterns was inspired by software design patterns. In software engineering, a design pattern is a general reusable solution to a commonly occurring problem software design. The same philosophy can be used to identify Impact Evaluation Patterns in different decision-making scenarios. An Impact evaluation pattern can be described as a generally reusable solution for a commonly occurring decision-making challenge in a particular scenario. For example, a product manager can use an Impact Evaluation Pattern for initial screening from sustainability perspective to decide if a set of new requirements should be selected for implementation in the product or not.”

On the second whiteboard in the room, Daniel sketches the template (Table 5, Fig. 1 Step 4): “Here you can see the basic structure for documenting the impact evaluation pattern—which is part of what we are discussing right now. I’ll keep explaining it while we continue.”

**Social Sustainability** Mick settles for that for the moment: “Okay, let’s continue with the social dimension. What have you got on your value map for that?” “There are customer capital values and network externalities. How is the relationship that you build with your customers? Are they loyal?” “They like our cars, and once they had one their likelihood to buy the same brand again is about 80%. I’m not sure though whether that applies to car sharing as well. We could establish a bonus system for frequent users.” “Good! How about network externalities?” “What is that supposed to be?” “It means the amount of other users of the software product that are relevant to the focal user. Applied to a car sharing service platform, we have to think about incentives we can offer a user for spreading the word about our service and making other people use it.” “Phew, you mean like family discount and stuff? The problem is that we diminish our revenue, so the business analysts are always reluctant to give such bonuses. However, we will find something.” “Alright, I’ll put it on the list.”

**Economic Sustainability** “Then let’s talk about the economic dimension”, says Daniel. “That’s the one you might already have sorted out the most. The values are maintainability, innovation value of technology and innovation value for market, differential advantage, and business agility.” “Yes, I guess we have elaborated on that for many hours.” “Just what I thought, then why don’t we directly move on to the environmental dimension? That was one selling point of your campaign draft, right?” “Yes, of course”, agrees Mick.

**Environmental Sustainability** “Let’s see what your value list says”, Mick continues, “Market requirements value, physical value with w.r.t. cost, and so on. These first two are about resource saving, right? That would increase the respective values.” “Yes”, Daniel agrees, “one of your market requirements would be to have an environmentally sustainable service, and you can consider various aspects for that—transport, i.e., local procurement, digital communication, traveling, and transport; then energy, i.e., energy used, and emission / CO2 from energy used;
waste, i.e., recycling and disposal; and materials, i.e., reusability, incorporated energy, and resources. The other part of resources and potential ‘waste’ to be considered are the working hours—on one hand spent in design and development and on the other hand as ‘waste’ in terms of partially done work, extra features, relearning, handoffs, task switching, delays, defects, etc.”

“That list is even longer than the one we calculated from—I will double check that with our business analysts. For a start, the transport in our service refers mainly to the vehicle availability. If there aren’t enough vehicles in a hot spot area, the service personnel have to move the vehicles accordingly. We definitely want to avoid that because it is costly in terms of emission and money. What is it with the sustainability value of technology?” Mick inquires.

Daniel replies: “You are potentially decreasing emissions by decreasing traffic—and I’m sure you will be able to find a lot more within an analysis of environmental optimization potential. You also have to evaluate how the desired system quality might affect the environment in a negative way, for example, by putting a lot of cars out there to ensure availability, you make a considerable impact again on the environment.” “True, we’ll have to perform an analysis on how they contradict.”

Table 5. Impact evaluation pattern for sustainability aspects

<table>
<thead>
<tr>
<th>Pattern Name</th>
<th>Impact eval. on sustainability aspects pattern for a product manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intent and Motivation</td>
<td>To perform a detailed value analysis with respect to sustainability.</td>
</tr>
<tr>
<td>Applicability</td>
<td>Analyze features to include in a product w.r.t. sustainability</td>
</tr>
<tr>
<td>Value aspects</td>
<td>Value aspects listed in Table 1-4</td>
</tr>
<tr>
<td>Consequences</td>
<td>//to be added when the pattern is put into actual use</td>
</tr>
<tr>
<td>Involved stakeholders</td>
<td>Product manager, domain expert, sustainability expert, process engineer, project manager</td>
</tr>
</tbody>
</table>

Impact Evaluation Pattern “Now we have a lot of scribbled notes on the whiteboard—what you called Impact Evaluation Pattern earlier on.” Mick gets back to the sketch on the whiteboard. “Yes.” Daniel emphasizes, “With the help of such impact evaluation patterns, the company can have tremendous benefits. An impact evaluation pattern presents a consolidated view of value aspects to be considered while deciding with respect to sustainability. Furthermore, it provides a common understanding and vocabulary, as well as acting as decision support to assure no value aspect is unintentionally overlooked. And finally, it enables a conscious impact evaluation (positive and/or negative) of relevant value aspects.” Mick likes decision support: “That’s good. And I can teach my staff to use the guideline instead of trying to mentally infuse my experience into them, as genuine experience cannot really be passed on.” “True”, Daniel adds, “and, furthermore, we can define corresponding rubrics that help to evaluate that selected measures, so you and your VP can see the direct impact.” “Rubrics? What would be an example for that?” “For example, for human capital value, you can assess general satisfaction, time per year spent on continued education, and employee fluctuation.” “Okay, that makes it assessable for management—for these metrics, we already have some kind of reporting, so I know where to get the data from.” Daniel wraps up the discussion. “Alright, I
hope I could show you how you can use the value map to identify optimization potential with respect to the different dimensions of sustainability.” “Yes, thanks, I feel quite prepared now for the next meeting with the vice president.”

In the meeting with the vice president, Mick will realize Step 5 of the process in Fig. 1, the vice president will take the decisions and Mick is responsible for their implementation. The Impact Evaluation Patterns will be reused for the assessment of Step 6.

5 Discussion: Transfer to Practice

The presented usage scenario is the first attempt to illustrate the approach and can by no means substitute the evaluation in a sufficiently sized industrial case study. The preparation of such a case study is under way, but as we are looking for academic feedback in parallel we offer our concepts for early discussion. We believe the approach is promising since its is based on a theoretically solid and empirically evaluated Software Value Map. The Software Value Map and impact evaluation pattern have been used in a case study at Ericsson for identifying value aspects to be considered for requirements selection from different stakeholders’ and they have been proven usable and useful. The industry practitioners did not only verify the benefits of having a consolidated view of value components, relevant for a particular Impact evaluation pattern, for decision-making; they also found the Software Value Map a step towards common definitions and understanding of value components enabling effective communication [20]. We expect to implement a similar case study for a sustainability analysis with equally positive results.

One important issue for consideration are conflicts that arise between different dimensions, as already mentioned in “Interrelationships” on p. 6. The explicit catalogue of values provides means to identifying such conflicts. However, the question of how such trade-offs can be solved while planning requires the prioritisation of goals. Which dimension will be considered most important in our future requires solutions in much broader terms than the approach at hand.

6 Summary and Future Work

In this paper, we have presented an approach to incorporate sustainability related value aspects while taking software product management decisions on the project, product, or portfolio level. Its usage is illustrated in a scenario where there is a dialogue between a consultant and a software product manager. As a first effort to factor sustainability as primary aspect in value-based software engineering, the approach still needs to evolve and be explored. The proposed list of sustainability related value aspects is ready to use but not necessarily comprehensive; value aspects and perspectives can be complemented as needed. Our next step is to evaluate the approach in an industrial setting with adequate complexity to gain resilient feedback on its application in practice.
Future work is to improve upon how the identified sustainability aspects should be measured in industry.

References


32. B. D. Steven. Using the balanced scorecard process to compute the value of software applications. In *ICSE’06 Proceedings of the 28th international conference on software engineering*, Shanghai, China, 2006. ACM.

