

# Who Is the Advocate? Stakeholders for Sustainability

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**Abstract**—While the research community has started working on sustainable software engineering recently, one question that is often asked still remains unanswered: who are the stakeholders? Who are the people who actually have an interest in improving the sustainability of a specific software system or of the discipline of software engineering itself? And who are the devil's advocates?

Having no explicit stakeholders is a problem as improvement of sustainability is challenging without a driving force. An objective that has no stakeholder is not likely to receive sufficient attention to be realized and will eventually disappear.

In this paper, we present four approaches of identifying stakeholders for sustainability in a given context: top-down by sustainability dimensions (individual, social, environmental, economic, and technical), by instantiation of a generic list, bottom-up by an organigram, and iteratively by an activity model according to the generic sustainability model. We furthermore analyze the feasibility by a small case study for each approach.

As the stakeholders are the key persons determining whether or not any objective is achieved, identifying the stakeholders for sustainability is crucial for successfully implementing sustainability support in a given context.

**Index Terms**—stakeholders; sustainability; requirements engineering; case study.

## I. INTRODUCTION

The Swiss Parliament asked a panel of philosophers, lawyers, geneticists and theologians to establish the meaning of flora's dignity, which led to a treatise stating that vegetation has an inherent value and that it is immoral to arbitrarily harm plants [18]. This may sound a little far-fetched, but it leads to the question of where responsibility actually starts and where we have to begin looking for stakeholders when it comes to sustainability.

This is one of the challenges we need to answer for a green software industry. For decision-making and incentives to invest in greener software, we need to identify sustainability stakeholders. This will also allow us to investigate the return on investments and economic aspects of green software development.

**Problem:** Supporting sustainability requires knowing the stakeholders, as the key challenge and success factor for all projects, hence also for sustainable or green software, is the support of stakeholders. Currently, there is a lack of identification methods of stakeholders for sustainability in software engineering.

**Contribution:** This paper presents four possible approaches to identifying stakeholders in software engineering who have

sustainability as one of their objectives. The first approach is top-down by identifying stakeholders according to the five dimensions of sustainability (individual, social, environmental, economic, and technical<sup>1</sup>) [13], [21]. The second approach is the instantiation of a generic list of sustainability stakeholders. The third approach is bottom-up by using the organigram (or organization chart) of the company in the given context. The fourth approach is performed iteratively by deducing the corresponding stakeholders for the activities of an instantiation of a generic sustainability model as described in [21]. We furthermore present a small case study for each approach.

**Impact:** If we can identify stakeholders for sustainability, it will be easier for software engineers to find incentives to invest in greener software, as they can be coupled to the objectives that these stakeholders already have. By finding the synergies, stakeholders can be convinced that sustainability can be achieved without sacrificing their other objectives. Additionally, together with these stakeholders we can check instantiated sustainability models with regard to completeness and correctness.

**Outline:** The remainder of the paper gives an overview of the related work (Sec. II), then presents the four approaches for the identification of stakeholders for sustainability (Sec. III), describes the conducted case studies (Sec. IV), discusses the approaches (Sec. V), and concludes with an outlook on future work (Sec. VI).

## II. RELATED WORK

The related work for the paper at hand is composed of two areas: stakeholder identification & management in sustainability research and stakeholder identification & management in requirements engineering.

### A. Stakeholder Identification in Sustainability Research

In sustainability research, we found work on stakeholder frameworks and stakeholder processes as well as case studies on stakeholder management.

1) **Stakeholder Identification:** Carroll and Buchholtz [8] investigate the social and political environment of business and explore the role of the corporation in current society. They provide an extensive analysis of stakeholders in business, their

<sup>1</sup>I.e. longevity of systems and infrastructure.

stakes, and how to consider them during business development and in corporate social responsibility. Their models serve as a basis for the work at hand. Wheeler et al. [29] analyze how corporate social responsibility and sustainable development relate to the creation of business value and how respective stakeholders need to be taken into account. Perrini and Tencati [23] propose a sustainability evaluation and reporting system, which monitors the overall corporate performance according to a stakeholder framework. Hemmati et al. [14] detail how to design multi-stakeholder processes. All these works provide helpful insights on stakeholder identification in other domains but none of them mentions stakeholders for sustainability in the area of software engineering.

2) *Stakeholder Management*: Bäckstrand [3], [4] analyses and advocates stakeholder partnerships and democracy in global environment governance. In contrast, Biermann et al. [6] doubt that multi-stakeholder partnerships already solve the challenge of sustainable development. Kolk [15] examines to what extent and how current sustainability reporting of Fortune Global 250 companies incorporates corporate governance aspects and how they deal with their stakeholders. Garvare and Johansson [11] present a conceptual model of stakeholder management and expand upon the relationship between organizational sustainability and global sustainability. Various authors provide studies of stakeholders in the domain of sustainable forestry, e.g. [5], [24], [26]. Van de Kerkhof [28] investigates stakeholder participation in transition management for climate change. Byrd [7] analyses the role of stakeholders in sustainable tourism development. Ayuso et al. [2] report on two case studies from Spanish business that use stakeholder dialogue for facilitating sustainable innovation. These works provide examples for how stakeholder management is performed in other domains, but again, no work could be identified that treats stakeholders for sustainability in software engineering.

### B. Stakeholder Identification in Requirements Engineering

The concept of stakeholders is central in requirements engineering and has been investigated by a number of researchers: Glinz and Wieringa [12] introduce the topic and define stakeholders in requirements engineering. Sharp et al. [25] propose an approach to identifying relevant stakeholders for a specific system. Decker et al. [10] explore the use of wikis for stakeholder collaboration. Damian [9] highlights the problem of dealing with stakeholders in globally distributed settings. Woolridge et al. [30] present an outcome-based model for assessing stakeholder risks that identifies deficits between expected and desired stakeholder impact and perceptions. Alexander propagates the “Onion Model” [1] as simple means to structure the stakeholders of a software system. All these works provide insights on stakeholder identification for software systems but none of them regards sustainability.

Mahaux et al. [17] applied Alexander’s Onion Model to a case study that investigated sustainability requirements, but does not detail any further on the stakeholders or the identification process.

In summary, various authors have recognized the need for stakeholder identification; however, to all our knowledge there is no approach to systematically identify sustainability stakeholders in IT. Therefore, we take the knowledge from Sec. II-A and apply it to requirements engineering.

## III. IDENTIFICATION OF STAKEHOLDERS FOR SUSTAINABILITY

Consider the situation of an analyst working on analyzing or improving the sustainability for a context (i.e. the concrete company or project under analysis). To ensure success of this undertaking, he needs to identify the involved stakeholders. To identify these stakeholders for sustainability there are four potential information sources that imply different, but simple approaches, which we describe in the following sections (see Fig. 1):

- 1) Analyzing the dimensions to find responsible roles, and matching them **top-down** to the context.
- 2) **Instantiating** generic lists of sustainability stakeholders for the concrete context.
- 3) Inspecting the context, understanding which concrete roles are involved, and matching them **bottom-up** to the dimensions.
- 4) **Iteratively** analyzing and refining a generic sustainability model.

For applying the method, we expect that there is always one predominant (most suitable) information source that determines which of the approaches shall be used.

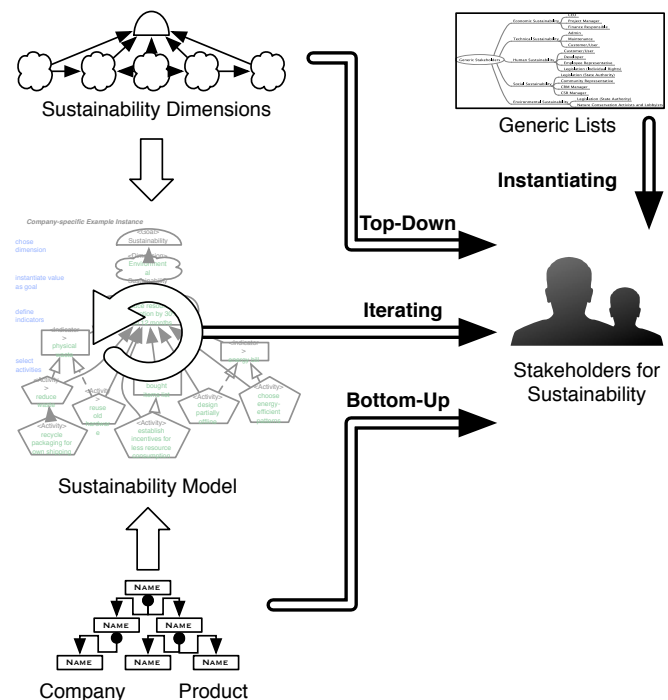


Fig. 1. Sources for sustainability stakeholders

### A. Approach 1: Top-Down using Sustainability Dimensions

Sustainability can be decomposed into five different dimensions. These dimensions specify different focus points and are connected with different roles. The dimensions are based on [13] and [27] and further specified and extended for software systems in [19].

*Source:* The sustainability dimensions. Following the definitions given in [19], sustainability can be seen from five dimensions:

- **Individual** sustainability refers to maintaining human capital (e.g., health, education, skills, knowledge, leadership, and access to services).
- **Social** sustainability aims at preserving the societal communities in their solidarity and services.
- **Economic** sustainability aims at maintaining capital and added value.
- **Environmental** sustainability refers to improving human welfare by protecting the natural resources: water, land, air, minerals and ecosystem services.
- **Technical** sustainability refers to longevity of systems and infrastructure and their adequate evolution with changing surrounding conditions.

*Task description:* The analyst inspects each dimension based on the above definition, and identifies roles that are directly or indirectly connected to this dimension. Afterwards, these roles are related to the concrete project or company in a top-down manner. The dimensions are mapped on the roles within the company. In case no roles can be found, the company needs to analyze if the missing dimension is important to the company and consequently consider creating a dedicated stakeholder role. Thereby, the analyst identifies who is affected by which dimension in this concrete company or for this concrete product. Typical roles that have stakes in social sustainability are managers, in economic sustainability the budget responsible, in technical dimension the administrators, and in environmental sustainability there is either a designated CSR<sup>2</sup> role or a gap.

### B. Approach 2: Instantiation of Generic Lists

Within a preliminary series of case studies we performed, we found that the outcomes of Approach 1 tend to repeat stakeholder roles and show potential for deriving a generic list of stakeholders. Thus, we decided to create a reusable, generic list of stakeholders that repeatedly appear in sustainability modeling. A similar approach of having generic lists of stakeholders is also very common in requirements engineering [1], where stakeholders are often identified based on reference models and professional experience. Such reference models in the form of generic check lists help to enable reuse.

*Source:* A generic stakeholder list. Based on the dimensions explained above and our experience with creating sustainability models, we created a generic list of stakeholder roles, which are independent from a concrete company [20]. The list is by no means complete and not intended to be so; instead,

TABLE I  
A GENERIC LIST OF SUSTAINABILITY STAKEHOLDERS

Dimension	Stakeholder	Description/Rationale
Individual	User	The user is affected by the system in various ways. For example, users of online learning courses educate themselves through software.
	Developer	The developer is heavily involved in creating the system. Aspects like sustainable pace and growth of the developer must be considered.
	Employee represent.	The mental and physical safety of individuals needs to be maintained. Employee representatives watch rights of employees involved.
	Legislation (indiv. rights)	Systems must respect the rights of their users. A legislation representative is a proxy for privacy and data protection laws.
Social	Legislation (state authority)	The state has a strong interest in understanding a system's influence on the society. In contrary to the individual rights legislation representative, the state authority representative speaks from the perspective of the state as a whole.
	Community represent.	In addition to the state authority, other communities such as the local government (e.g. the mayor) or non-government clubs might be affected by a software system. A complete analysis must take their views into account.
	CRM	The Customer Relationship Manager (CRM) is in charge of establishing long-term relationships with their customers and creating a positive image of the company.
	CSR manager	Some companies created the dedicated position of the Corporate Social Responsibility (CSR) manager, who develops a company-specific vision of social responsibility.
Economic	CEO	The chief executive officer integrates sustainability goals into a company's vision.
	Project manager	It is very important to have the project manager agree in what ways the project should support sustainable aspects as he decides on prioritization with conflicting interests.
	Finance responsible	As sustainable software engineering often also affects the budget, many financial decisions have to be made to implement a sustainable software engineering model in a company.
Environm.	Legislation (state authority)	Environment protection laws are in place to ensure sustainability goals. These laws must be reflected in the model.
	CSR manager	The CSR manager is often also responsible for environmental aspects.
	Activists /Lobbyists	Nature conservation activists and lobbyists (e.g., WWF, Greenpeace, BUND)
Technical	Admin	The administrator of a software system has a strong motivation for long-running, low-maintenance systems, making his work easier.
	Maintenance	The hardware maintenance is interested in a stable, long-term strategy for installation of hardware items.
	Customer	Users are interested in certain longevity of the systems they are using. This refers to user interface and required soft- and hardware.

<sup>2</sup>corporate social responsibility

we plan to extend it over time and add stakeholders based on new expertise. The current state of the generic list is described in Table I. We would like to offer it as reference checklist for other researchers and persons responsible for sustainability.

*Task description:* The analyst checks the generic list and instantiates the roles where appropriate. Obviously, some of the roles need to be adapted to the context; yet, they give a reasonably good initial idea.

### C. Approach 3: Bottom-Up Analysis of Organigrams

In Approach 1 and 2, we analyzed dimensions, found generic roles and mapped them to concrete roles in the company or product in a top-down manner. In contrast, one could also take the company's or project's role model and identify which of these roles are related to the sustainability dimensions. We consider this a bottom-up approach.

*Source:* A company's or project's organizational diagram. Many companies create structured representations of the company's or projects role model—e.g. as an organigram—in order to visualize the involved institutions and individuals. Even though we will furthermore only consider organigrams, this approach also works with other representations of the role model, e.g. lists of roles in spread sheets.

*Task description:* The analyst identifies the existing roles in the present context—for example, through an organigram. He then inspects each role and maps it on the dimensions of sustainability.

### D. Approach 4: Iterative Analysis of the Sustainability Model

In addition to the bottom-up and top-down approaches from Approach 1-3, another approach is iterative based on a sustainability model that was introduced in [21] and makes the goal “sustainability” tangible in a concrete context. In [21] and [20], we furthermore explain how to derive such a concrete sustainability model from a generic reference model. Moreover, after having an initial sustainability model, the analyst can also use it to identify sustainability stakeholders. These new stakeholders will lead to new elements in the sustainability model, which might lead to new stakeholders and so on.

*Source:* An instantiated sustainability model as defined in [21] (and depicted exemplarily within Fig. 5). The sustainability dimensions can be derived into a generic sustainability model in order to make sustainability explicit [21]. For each context, the generic sustainability model is instantiated into a product- or company-specific model that describes the values, activities and indicators that specify the exact definition of sustainability for this context.

In short, the model comprises the generic sustainability model (M1 level), the respective meta model behind it (M2), and the instances (M0) derived for specific processes and systems. The generic sustainability model adheres to the following metamodel: Dimensions are represented by a set of values. Values are approximated by assessable indicators, influenced by activities and affected by regulations.

The generic model (M1) is a library that can be structured in three levels: the top level contains the five dimensions; the middle level consists of (currently) 51 values, 5 generic indicators, and 6 regulations; and the lower level is formed by 38 activities. For example, for the dimension *social sustainability*, the spirit of the *community* is an important value that can be decomposed in different values such as *trust* or *education*. The education value is regulated, amongst others, by *human rights*. This value can only be assessed roughly and individually by indicators, where one indicator contributing to that assessment is the *level of graduation* of a person. Education is fostered by different activities, such as *knowledge management*, *education programs* or *mentoring* [22] (see excerpts from model instances in Fig. 5). A process or requirements engineer instantiates this generic model into a context-specific sustainability model by refining the rather abstract activities into concrete actions and defining specific indicators to measure the success in the concrete domain.

For the work at hand, the generic model is one input for the identification of stakeholders and instantiating the model for a specific context is a means to structure the objectives and interests of the identified stakeholders.

*Task description:* Assuming the analyst has an existing initial sustainability model at hand, he can iteratively analyze the model for lacking stakeholders. By going through the model items, such as values, activities and indicators, he can check a set of questions: Who is actively involved in this item? Who is (passively) affected? Who is interested? When a new stakeholder is identified, the analyst can interview this new stakeholder and extend the model based on this new information. This will lead to a more detailed sustainability model, which will raise new questions of stakeholders and so forth.

## IV. CASE STUDIES

To understand the benefits and limitations of the approaches, we conducted a small case study for each of the four approaches.

### A. Top-Down Approach: Munich Software Company

For the top-down approach, one of our master's students (Susanne Klein) created a sustainability model for a Munich-based software company with about 100 employees. To understand the company's needs and habits, the student conducted a series of interviews. To ensure that all domains of the company are covered, she analyzed which stakeholders could be available for each dimension (see Fig. 2). After she identified various different roles, she asked for feedback from the organization, which led to addition of four more roles and rejection of one role (sales). These decisions were based on the company specifics.

These stakeholders were the basis for a set of interviews and discussions, in which it turned out that the role of a person does not necessarily reflect the subjective perception of importance of the sustainability dimensions. For example, it turned out that for many developers the dimension of technical

sustainability was less important than social and individual aspects. Also remarkable is the role of the *innovation consultant*, who was supporting the company in long-term development, including the environmental dimension.

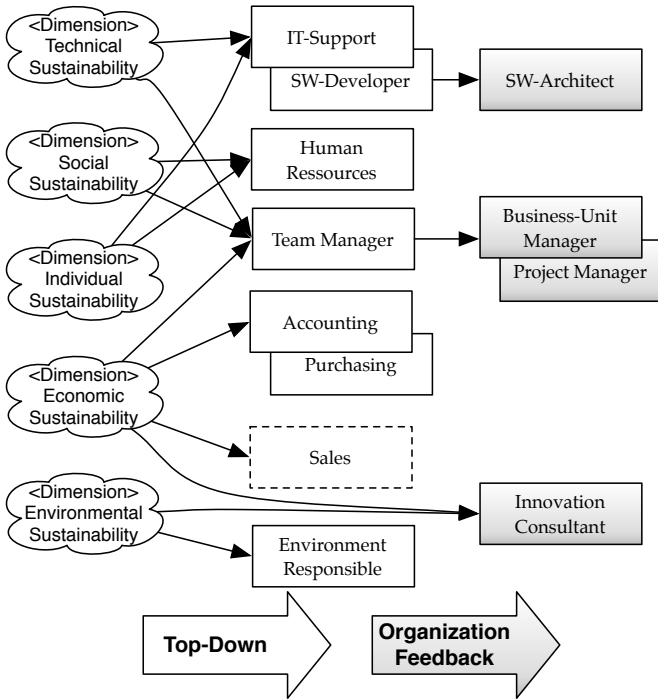


Fig. 2. Mapping of dimensions to roles in an IT company

### B. Instantiation Approach: Car Sharing Platform

In a previous study we instantiated the sustainability model for understanding its applicability to the car sharing platform [21]. For this study we instantiated the generic stakeholder list from Section III-B for the DriveNow car sharing program, which is a mobility service offered by German car manufacturer BMW. The result is displayed in Fig. 3.

The instantiation is straightforward. Roles like CEO and CRM can be directly mapped to the company, as nearly all companies have representatives with this role. Some generic roles have several instances. For example, we have two roles for the generic role *maintenance*: software maintenance for the implemented solutions, as well as car maintenance that is responsible that all cars are checked and repaired regularly. Also interesting is that the mayor of Munich is represented as a stakeholder, as the German Car Sharing Association quotes the mayor to be a strong supporter of car sharing platforms [16]. This is a good example for making the important stakeholders (here: politics) explicit.

### C. Bottom-up Approach: Project Organigram

In contrast to going from dimensions to roles, one can also take existing organigrams of the company or project and understand which roles can be mapped to which dimensions.

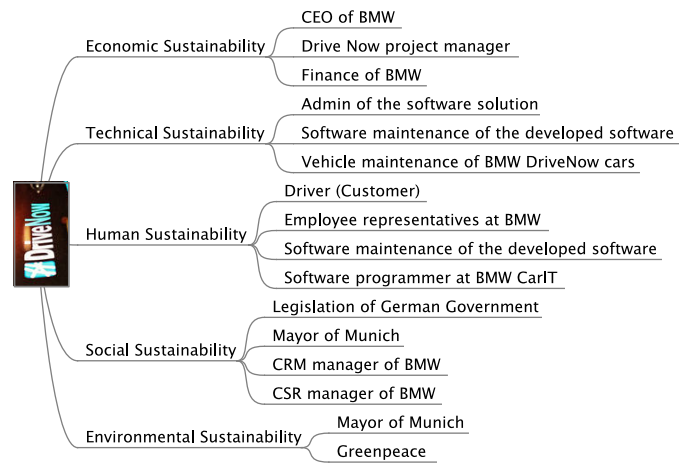


Fig. 3. Stakeholders of the DriveNow service based on generic list

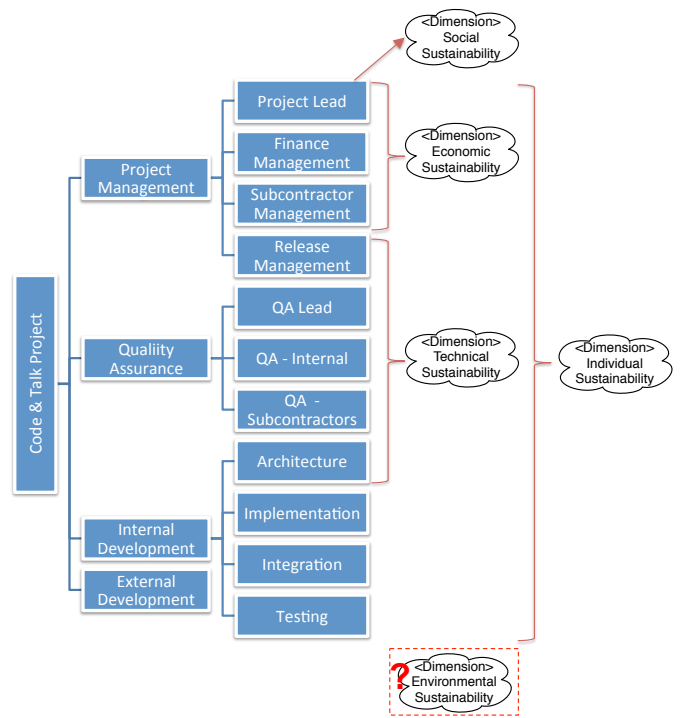


Fig. 4. Roles of an IT project *Code & Talk* and mapping to dimensions

The organigram in Fig. 4 is taken from a project management course at TUM and depicts a typical medium to large-sized software project structure (here named *Code & Talk*). Some roles are straight-forward to map: Architecture, quality assurance (QA) and release management have a particular interest in creating a sustainable technical architecture, management tasks are mostly dedicated to keep an overview over finance, and all involved persons have interest in individual sustainability. For social sustainability, the only role that can roughly be connected is the project lead. More alarming, no role could be identified for environmental sustainability.

This highlights several issues in this project: Having the

project lead as the single role being involved in creating a professional team atmosphere is a problem, that is often targeted by creating a dedicated role for team management. The same holds for individual sustainability, as there is no single person responsible. However, this might be taken care of outside of the project. Lastly, there is a lack of responsibility for environmental sustainability.

The analysis gives hints to where too many or too few stakeholders are involved with certain dimensions. This must lead to follow-up questions regarding the goals of this project and company. If project or company goals are under-represented, the company should consider creating dedicated roles for these stakeholders.

#### D. Sustainability Model Iteration Approach: RE Conf 2013

The fourth option to identify stakeholders for sustainability is to start with an instantiation of the generic sustainability model that includes actions and activities developed to support sustainability in its different dimensions throughout a given context [21]. Such an instance has been elaborated for the upcoming 21st RE conference (RE'13). Given the envisioned activities, they can be assigned to stakeholders that are identified as capable for taking care of the actions. The sustainability model, as well as the identification and assignment of stakeholders for the activities at the 21st RE conference are illustrated in Fig. 5.

For the RE'13 we can derive various stakeholders from the sustainability model. One can see that there is a general stakeholder, the sustainability chair, who takes care of the overall coordination of the sustainability activities; yet, it is important to understand that there are responsible stakeholders for other individual tasks. For example, triggering more interaction as part of the individual sustainability measure for development and growth, i.e., how people can make the most of the conference is a task for the interaction chair.

Naturally, there are a considerable number of assignments for local chairs, general chairs, and other roles, but it is important to note that also the attendees have a crucial responsibility for achieving the objective of sustainability at the conference. Without their support, the undertaking will simply not lead to the desired results.

## V. DISCUSSION

This section discusses the advantages and drawbacks of the method as well as of the individual approaches used for the stakeholder identification.

### A. Comparison of Approaches

Each of the approaches for identifying stakeholders has its advantages and disadvantages. Yet, an industrial evaluation with more formal criteria is subject of future work. We performed the case studies ourselves, which leads to a subjective, informal comparison of the methods. The most complete set of stakeholders will be found by using their combination.

*Top-Down* identification allows for a rather general reflection on the sustainability dimensions. However, it may be less

efficient when compared with instantiation of generic lists, as there is no further input than the definition of the sustainability dimensions. Consequently, the success relies completely on the creativity and cleverness of the person performing the identification.

*Instantiation* of generic lists is probably the most efficient approach (which is probably the reason why these generic lists are mostly used for stakeholder identification in professional RE [25]). On the downside, there is no thinking “outside of the box” involved even though creativity is probably important in order to involve all relevant roles.

*Bottom-up* analysis is very practical and down-to-earth, i.e., with the interviews and lots of input this approach actively includes the employees. At the same time, it is the most time-consuming approach.

*Iteratively* analysis the sustainability model for the identification might be especially beneficial as a closure at the end of the analysis, but it is not as straightforward as the other approaches.

### B. Benefits and Limitations of the Stakeholder Analysis

For assessing how effective and how efficient the approach is, we can only refer to our experiences from the first case studies. For each of the case studies the approach identified more stakeholders for sustainability than we had considered originally. This may indicate that the approach help to discover stakeholders that might be missed otherwise.

Consequently, when all stakeholders are involved, who actually do have an interest in sustainability, it is possible to sketch a more complete picture of the subject under analysis through decreasing the risk of forgetting any sustainability issues that should be considered. This is the case for stakeholder identification for sustainability, just as it is during any requirements elicitation activity where stakeholders have not been identified correctly [1].

However, this paper presents only a small set of case studies that were performed so far and, currently, there is no tool support and only the guidance provided in this paper. For further evaluation, we will apply all four methods on one set of case studies. Furthermore, for industrial application, we need to extend that guidance so that industrial collaborators can perform the approach by themselves.

## VI. CONCLUSION

This paper proposes method consisting of four approaches to identify stakeholders for sustainability in different contexts. We offer four approaches for this identification: top-down from the sustainability dimensions, instantiated from a generic sustainability stakeholder list, bottom-up from the organigram of a company, or iteratively in parallel with the development of an instance of a sustainability model.

*Results:* We present case studies to illustrate the different approaches for our method. Two of them are performed in collaboration with industry—i.e., a large automotive company and a medium-sized software development company. The other two stem from an academic context, one of them being





the conference management of the international requirements engineering conference, and the other one a hypothetical case study on IT project management that is used throughout our IT processes and management course.

The case studies revealed various stakeholders for sustainability that are already present, but not yet seen in this context. They have to be taken into active consideration by an analyst for sustainability. The studies also revealed missing responsibilities that may have to be filled by new roles or new responsibility assignments. For example, if a company decides they want to improve their environmental sustainability, a stakeholder needs to be identified or a specific role created, because otherwise the objective of improving environmental sustainability will not be pursued in an effective way.

*Future Work:* The next step after the presented validation, which was performed by the developers of the approach, is an evaluation performed by external subjects in an industrial context. Furthermore, we envision tool support that guides the identification process using the different methods as options.

*Advocate for Sustainability:* After all, who is the advocate for sustainability? We have identified a number of stakeholders for the dimensions of sustainability in different context. Roles that reoccurred across case studies are captured in the generic list in Tab. I, which serves as a first reference checklist for further research and practice. We are positive that successfully identifying the stakeholders for sustainability will help ensure that this objective receives the deserved attention.

#### ACKNOWLEDGMENT

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