Development of Information Systems for Transparent Corporate Sustainability Using Data-Driven Technologies

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Abstract. Corporations, as influential players in a global environment, face increased pressure of the society and governments to assume responsibility for the consequences of their corporate actions. Although information technologies advance rapidly, data collection still heavily relies on manual input, static reports and to a broad extent the integration of stakeholders is not yet the general rule. Data-driven technologies like Participatory Sensing methods, Linked Open Data practices or Geographical Information Systems are useful methods to collect, aggregate and disseminate information. This paper outlines the problem scope, the solution approach and the research plan for my doctoral thesis which explores the potential of these technologies to improve the transparency of corporate sustainability using a design-science based approach. Experiences gained by designing and evaluating IT artifacts are expected to bring new insights about the relation of IT and corporate sustainability where existing research is still sparse.

Keywords: Corporate Sustainability, Participatory Sensing, Linked Data, GIS.

1 Introduction

The world has never faced greater challenges: over-consumption of finite natural resources, climate change, and the need to provide clean water, food and a better standard of living for a growing global population [26]. In the last decades, the term "Sustainability" has become increasingly popular, as a strategy to tackle these challenges. In 1987, the Brundtland Commission, a UN world commission on environment and development, coined the term "sustainable development" as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [4].

1.1 Corporate Sustainability

Corporations, as main players in a global environment, face increased pressure of the society and governments to assume responsibility for the consequences of their corporate actions. As a result, companies started to integrate next to

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economic, also social and environmental aspects into their visions, missions and goals [22].

However, many companies still rely on purely reactive strategies and understand sustainability as an opportunity to enhance their company reputation, save resource costs, address new customer groups, attract employees or to gain easier access to capital [18,9]. It is still not common knowledge that corporate sustainability is also important beyond the business case, as a vital requirement for companies' long-term existence established on a secure resource base [5].

Sustainability drivers are strongly related to the interests of different stakeholder groups, therefore it is essential for companies to integrate their opinions into business considerations and to provide stakeholders with a transparent view on the company's sustainable behavior. Following this premise, companies increasingly initiate stakeholder dialogues and publish Corporate Social Responsibility Reports. Since these actions require time and resource intensive processes, results are commonly published only on an annual basis in form of static, textual reports. However, in times of significant progress in the field of information technologies, stakeholders' demands for real-time information is a logical consequence. This leads to the presumption, that sustainability reporting practices are still more aligned with reactive strategies focused on accountability rather than on proactive value-adding strategies [28].

1.2 Data-Driven Technologies

Innovative data-driven technologies provide useful methods for the effective collection, dissemination and visualization of information. These technologies are the main enablers to improve stakeholder integration and communication and help companies to develop a more transparent picture of their corporate sustainable behavior.

With increasing access to the internet, we can state an emerging trend to outsource different tasks to "the crowd". More and more people are equipped with a smart phone, which possesses a number of different sensors which can be utilized for collecting data about its environment. These devices can not only be used for automatic sensing but they can serve as input facility for human observations, a concept referred to as "People as Sensors" [23]. These new forms of data collection can be applied in companies to monitor environmental and social aspects which they have not been able to monitor before or not in an efficient manner. For example, employees or people living around a production site could be questioned about environmental conditions in the firm, e.g. odor or smoke emissions. Responses can be tracked and visualized automatically, which provides other stakeholders, e.g. decision makers with insights about very remote production sites. The utilization of these participatory sensing methods, enables collection of observations and measurements in real-time through mobile devices and we are able to systematically integrate stakeholders into the sustainability data collection process.

Another recent important approach in the area of data-driven technologies is the Linked Open Data initiative. The term Linked Data refers to a set of best

practices for publishing and connecting structured data on the Web best preserving its semantics [2]. The adoption of these practices has lead to the extension of the Web with a global data space connecting data from diverse domains such as governments, companies or scientific publications [2]. Linked Open Data could be applied in the corporate sustainability domain in two ways (1) as possible data source to integrate data from stakeholders, e.g. information about social indicators from local governments, regional data on climate change from the world bank and (2) as a channel to disseminate sustainability information in a structured format, e.g. for the exchange with other companies like business customers.

A further technology with a large potential to support stakeholder demands is the integration of Geographic Information Systems (GIS), to capture, store and analyze spatial information. Obviously, especially in the case of environmental information related to physical locations, a spatial representation of corporate sustainability information is very promising to provide an intuitive understandable format of information, e.g. resource usage or air quality information. One specific type of GIS, namely "Participatory GIS", aim to utilize GIS technology in the context of the needs and capabilities of communities that will be involved with, and affected by, development projects and programs [1]. In a corporate sustainability context, these systems could enable a more interactive representation of sustainability reports, by giving stakeholders the opportunity to not only exploit, but also add information, e.g. by pinning concerns, comments or questions to the same map. mes [1]. In a corporate sustainability context, these systems could enable a more interactive representation of sustainability reports, by giving stakeholders the opportunity to not only exploit, but also add information, e.g. by pinning concerns, comments or questions to the same map.

1.3 Research Question

In academic research, a central role is attributed to Information Technology and Systems in the quest for advanced corporate sustainability, as these have been the greatest force for productivity improvement in the last half of the 20th century [6,16,27]. Nevertheless, research in the field of Information Systems on corporate sustainability is still not widely distributed. My doctoral thesis, aims at a contribution to close this gap and specifically focuses on how data-driven technologies can increase the transparency of corporate sustainability.

In particular, I will address the following research questions:

1. How can participatory sensing methods be applied to monitor environmental and social sustainability in companies?
2. Which role can Linked Open Data play for the collection of corporate sustainability data? How can corporate sustainability information be published in the Linked Open Data Cloud?
3. How can GIS be utilized for interactive sustainability reporting?

As the research outlined in this paper is in an early stage, listed research questions are rather broad and will have to be refined in a later phase. In general,

the problem area to be investigated is clearly neither a purely technical, nor a purely economic one. Instead, a solution has to integrate technical, economic as well as social aspects. Existing literature in this context is sparse, accordingly requirements in this area are not clear yet. Therefore, this paper proposes to classify this as a "wicked problem", best solved by applying a design-science based approach (See Hevner et al [10]). Design science relies on the development and evaluation of IT artefacts, to be able to better analyze the problem domain and to deliver steps towards the problem solution. Therefore, the main objective of the thesis is the development and evaluation of software prototypes based on selected data-driven technologies with the goal to examine the potential of these technologies to increase the transparency of corporate sustainable behavior.

The expected contributions include on the one hand, identified requirements regarding the functionality and design of corporate sustainability information systems based on experiences gained during the design and evaluation process, and, on the other hand, the description of the developed design variants and according advantages and limitations identified.

2 Related Work

The problem studied in this paper resides at the intersection of two domains: Corporate Sustainability and Information Technology and Systems.

In IS literature, the area of IS support for corporate sustainability has been recently structured by various researchers. Melville [16] develops a conceptual framework and a research agenda to expedite development and adoption of information systems for environmental sustainability. Elliot et al. [6] compile a holistic, trans-disciplinary, integrative framework for IT-enabled business transformation as a research agenda. Watson et al. [27] create a research agenda to establish a new sub field of energy informatics, which applies Information Systems' thinking and skills to increase energy efficiency frameworks. However, there is no clear notion about the role of Information Systems with regard to corporate sustainability yet.

As this thesis will adapt a more technology-oriented approach the most relevant work is related to the three technologies in the focus of this study:

2.1 Participatory Sensing

Participatory Sensing systems have been developed for various application scenarios with relation to environmental sustainability in general. Mun et al. [17] developed a participatory sensing application that uses location data sampled from everyday mobile phones to calculate personalized estimates of environmental impact and exposure. Peterova and Hybler propose a "Do-It-Yourself Environmental Sensing" approach, which enables citizens to measure pollution with immediate feedback [21]. The application "BudBurst" enables citizens to monitor flowers and plants as the seasons change and thereby help scientists to monitor the regional impacts of climate change [8]. There are also non-academic

endeavors to use participatory sensing methods to collect data from voluntary citizen scientists e.g. Save-the-Redwood [24] users can add their observations about the location and condition of redwood which helps conservation agencies to understand climate change related impacts to redwood. However, no research has been found which applies participatory sensing methods in a corporate context.

2.2 Linked Open Data

In the domain of sustainability, the work of Phuoc et al. [14] can be mentioned as an effort to publish environmental sensor data in the LOD-cloud. Furthermore, Zapico et al. [29] developed a web service that delivers life cycle assessment information about different products openly, linked and reusable. The project Sourcemap [3] integrates linked open data to display supply-chain information of products. In the corporate context, some approaches demonstrate how to link enterprise data. Garcia and Gil [7] demonstrate how corporate financial reports present in XBRL-format can be published and linked to the LOD-cloud. Hondros [11] describes a content architecture based on OWL, RDF and XHTML that is used to build a standard representation of legal content, allowing publishable assets to be integrated across the enterprise.

2.3 GIS

Geographical Information Systems, and especially Participatory Geographical Information Systems have been widely applied in the area of environmental sustainability (e.g. for community-based natural Resource Planning [15], [25] or community carbon monitoring [13]). One of the most successful projects in the area of participative mapping is the Ushahidi project [19], which enables citizens to report an incident, event or observation for a specified location. In the enterprise context, Keating et al. [12] discuss challenges of the application of GIS in enterprises from a management-perspective.

2.4 Synthesis

Data-driven technologies have been applied in various areas to collect or disseminate sustainability data. Existing research mostly focuses on sustainability in a broader context, e.g. on country or city level. Little of the existing work approaches the topic of sustainability from a company-internal perspective, accounting for the specific information flows, sustainability aspects and information needs in the context of corporate sustainability.

3 Research Hypotheses

According to the stated research questions, the thesis should more concretely evaluate the following hypotheses:

1. Participatory Sensing methods can be applied to integrate stakeholders into the collection of data about social and environmental aspects (RQ 1)
2. The Linked Open Data Cloud is a possible Data Source for monitoring environmental and social aspects in a company's environment (RQ 2)
3. Linked Open Data practices can be utilized to publish and link corporate sustainability information (RQ 2)
4. GIS support companies to represent sustainability information in a dynamic, interactive and stakeholder-specific format (RQ 3)

4 Methods / Work Plan

Each of the hypotheses follows a four step process: (1) Problem understanding (2) Design (3) Evaluation (4) Communication (adapted from Hevner et al. [10]). As depicted in figure 1, this process is not linear, but it involves iterations (See also Pfeffers [20]).

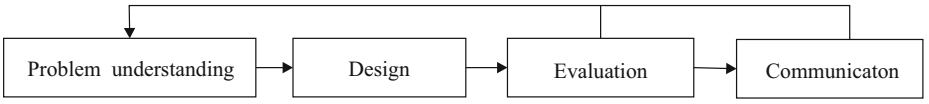

Fig. 1. The Design Science Process [10,20]

In this thesis, the design science process applies on both a macro-level and a micro-level.

On a macro-level the problem to be studied is more generally, how data-driven technologies can be applied to increase the transparency of corporate sustainable development. From that perspective, an evaluation of different technologies can be seen as an assessment of possible design alternatives. These would be evaluated separately and in comparison to the other design alternatives, and eventually results are communicated in form of a PhD-thesis (See figure 2).

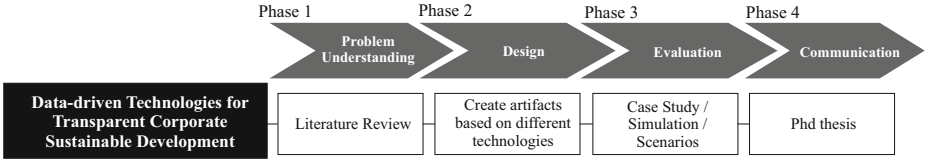

Fig. 2. Research Plan - Macro-Perspective

However, each of these design alternatives address different sub-scopes of the main problem scope and can thereby be seen as independent problems on a micro-level perspective. Therefore, each of the alternatives and according hypotheses will be evaluated separately by going through the main phases of the design science process (See figure 3).

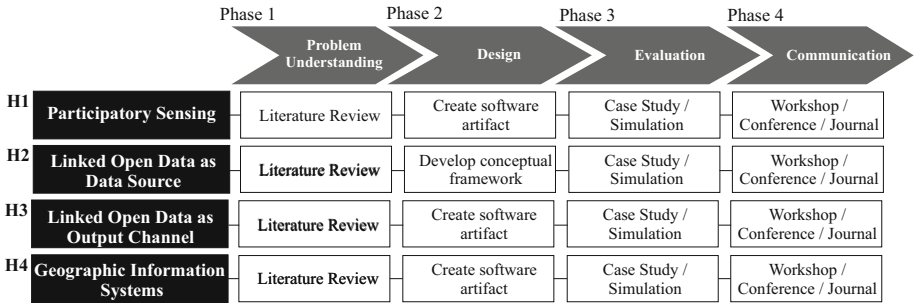

Fig. 3. Research Plan - Micro-Perspective

4.1 Problem Understanding

For all three hypotheses, the task of problem understanding will be mainly based on existing literature from different domains. Previous findings in the field of stakeholder-management, corporate sustainability and enterprise reporting will help to understand the problem and requirements from a business perspective. Existing knowledge in the fields of sensing, semantic technologies and GIS will provide important fundamentals from a technical perspective.

4.2 Design and Evaluation

Depending on the investigated technology, we will have differentiated design and evaluation phases:

Participatory Sensing (H1). In the design phase, the IT artifact to be created, is a prototypical software system that can be used in companies to collect data about environmental and social aspects from observations reported by stakeholders via their mobile devices (e.g. employees, residents around production sites). According to our plan, this prototype will be evaluated in a real-life application scenario with an industry partner in a case study. Alternatively, a simulation with artificial data or a descriptive evaluation based on scenario construction could be applied. Thereby, we expect to learn about business requirements to the design of data collection mechanisms for corporate sustainability data.

Linked Open Data as Data Source (H2). We will develop a technological framework to study in depth the potential of the LOD-cloud to serve as a data source for the collection of social and environmental aspects about the company's environment. A critical factor to be investigated is data source reliability, which still is an open problem in the Linked Data Project. The resulting framework should outline both a process for the identification of relevant Linked Open Data and mechanisms to integrate this information with other sustainability data. It will be evaluated descriptively by illustrating how this framework could be applied in exemplary scenarios.

Linked Open Data as Output Channel (H3). A software artifact will be designed which facilitates publishing of corporate sustainability information (e.g. corporate sustainability reports) in RDF format and linking it to existing information present in the LOD-cloud. This prototype can be evaluated by a simulation involving open corporate data, which is freely available on many company websites in form of reports. Expected outcomes include lessons learned about possibilities to represent sustainability data using ontologies and to link it to existing data sources.

Geographic Information Systems (H4). Based on available Open Source systems a prototype will show that participatory GIS can be used to integrate stakeholders into the mapping of spatial data in sustainability management tasks. The artifacts' utility should be demonstrated by a simulation relying on artificial data and descriptively by illustrating detailed application scenarios. It is expected to learn about the potential to represent corporate sustainability data using maps and about requirements of internal and external stakeholders towards a corporate sustainability GIS.

4.3 Communication

Intermediate findings and results from evaluating different technologies, will be reported on workshops, conferences and journals. Feedback from peers can lead to changes in developed design alternatives and repeated evaluation activities.

5 Conclusion

Adapting a design-science approach, in my PhD thesis, I want to analyze how innovative data-driven technologies can be utilized to increase the transparency of corporate sustainability. Specifically, the potential of participatory sensing methods (RQ1), Linked Open Data practices (RQ2 & RQ3) and Geographic Information Systems (RQ 4) to be applied for sustainability data collection and dissemination, should be investigated. The thesis aims to contribute by providing lessons learned from the development and evaluation of IT artifacts about business requirements and design principles for information systems solutions in the corporate sustainability domain. Applied evaluation methods include observational (case study), experimental (simulation) and descriptive (scenarios) approaches.

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