Companies as Drivers of Sustainability – Towards Requirements for an Integrative Sustainability Risk Management System

Andreas Thöni
Vienna University of Technology, Vienna, Austria.
andreas.thoeni@tuwien.ac.at

Lisa Madlberger
Vienna University of Technology, Vienna, Austria.
lisa.madlberger@tuwien.ac.at

Alexander Schatten
Sophisystems
Vienna, Austria.
alexander.schatten@sophisystems.com

ABSTRACT
With growing global population, economy and resource consumption we already have touched or even exceeded planetary boundaries. Sustainable development urges us to act in a socially and environmentally responsible way. Companies with resource and labour intensive production processes play an important role achieving a sustainable economy. As expectations of various stakeholder groups grow, sustainability becomes more and more important for company internal decision making. Managing sustainability is one of the key issues as they can have severe impacts on a company's performance and therefore are of interest for multiple stakeholders. Hence, a software system supporting sustainability risk management has to respect the information needs of these stakeholders. This paper follows the information subset model defined by Szyperski, who in principle suggests that in a "perfect world" objective and subjective information needs as well as information supply fully overlap. Following a literature-based approach, the information needs in the corporate sustainability domain are analyzed with management being the key stakeholder. Future research needs to examine how these information needs can be adressed by choosing the right input sources, analysis modules and output approaches.

Keywords
Sustainability Risk Management; Stakeholder requirements; Information Needs, Information Subset Model

SUSTAINABILITY IN THE BUSINESS CONTEXT

Current economic growth, production and consumption patterns are demonstrably not sustainable. The global population was growing just within the last century from about 2 billion in 1930 to about 7 billion in 2011. Not only global population was growing exponentially, so did the global economy and agriculture and parallel to the economic growth, resource, energy consumption and waste production. Today 4/5th of the ice-free surface is under direct human influence [2]. Research of Rockström et al. tries to derive planetary boundaries for the along 10 parameters/systems, most systems indicate an exponential curve towards assumed save planetary boundaries [20].

Furthermore, consumption of resources is extremely unevenly distributed. If the whole world today would show material consumption like the US or Europe, *"global consumption would rise elevenfold"* [22]. Sustainable development aims at achieving a more equal usage of natural resources while at the same time respecting planetary boundaries (environmental sustainability) and at a fair treatment of employees and communities globally (social sustainability).

Some activists focus on changing consumption patterns (bottom-up approach). While this is an important approach, recent analysis indicate, that top-down approaches (or combined approaches) can be more effective. For a start, all of the identified planetary boundaries: *climate change, biodiversity loss, nitrogen cycle, phosphorus cycle, stratospheric ozone depletion, ocean acidification, global freshwater use, change in land use, atmospheric aerosol loading and chemical pollution* are obviously strongly influenced by industrial and agricultural activity. Moreover, global economy (and thus ecology) is dominated by relatively few companies. Hence some Non-Governmental Organizations (NGOs; like WWF) are working closer with transnational corporations, arguing that the leverage is larger if it is possible to enhance business practices of a few dominating players in the market [30]. On the one hand, the direct influence is significant; on the other hand, the influence via supply chains and public perception is considerable. It seems reasonable to understand companies as main drivers for sustainability.

Companies' endeavors in the global quest for sustainability can be summarized under the caption "Corporate Sustainability". From a business perspective, derived from the general notion of sustainability, corporate sustainable development can be seen as the task to meet the needs of a company's direct and indirect stakeholders (such as shareholders, employees, clients, pressure groups, communities etc.), without comprising its ability to meet the needs of future stakeholders. But sustainable development goes beyond Corporate Social Responsibility marketing activities, as many corporations eventually understand the obvious, namely that future business will not be possible under unsustainable conditions. Thus, the role of companies can be seen as two-fold (1) they have to ensure their own long-

term existence and (2) they contribute to the sustainability of the society as a whole [10].

The pressure of different stakeholder groups like the society, NGOs, media, as well as governmental regulatory requirements "push" companies to perform corporate sustainability initiatives in order to anticipate damage or further pressure to the company and its reputation. Differently, companies proactively increase corporate sustainability because of "pull" factors which represent opportunities to improve the position of the company e.g. cost savings as a result of energy reduction [21].

Regardless whether looking at push or pull factors, both the damage which can result from an incident caused by "unsustainable" corporate behavior and the missed opportunities connected to potential sustainability-related savings and improvements can be seen as risks related to specific stakeholder groups. This damage may in particular include public perception towards a company potentially resulting in economic losses.

This paper aims to identify important information needs posed by different stakeholders for a sustainability risk management system.

RELATED WORK - IT SYSTEMS FOR SUSTAINABILITY

One important thought in literature that addresses the scope for IT systems is the need to include the whole supply chain when discussing sustainability. Kogg and Mont [14] highlight the importance of life-cycle thinking across the supply chain when considering the sustainability of a product. They build on the global value chain and supply chain management theory: Sustainability management can be exercised directly or indirectly; directly through criteria setting. The indirect approach includes influencing, monitoring and testing other actors (e.g. through third parties or by implementing standardized certification schemes), and is important as global value chains can include hundreds of suppliers in multiple tiers.

Considering this scope of sustainability management, other authors highlight the importance of information technology. For example Piotrowicz and Cuthbertson [17] and Srivastava [23] note the usefulness of IT with regard to sustainability in supply chains on a general level. In the supply chain setting the need to exchange information has been underlined in the early 2000s and systems have been proposed (e.g. Carlson et al. [6]). Klassen and Vereecke [13] also stress the need to include the whole supply chain and underlined that a company can be accountable for their suppliers if it can influence their behavior. Social issues bear large operational risks. Based on 5 case studies they develop an integrative framework covering supply chain responsibility, risk and performance management as well as capabilities. For risk assessment and mitigation they highlight the importance of the dimensions *location*, *management system* and *certifications* as well as of *monitoring* in general. Describing multiple monitoring tools, Klassen and Vereecke [13] acknowledge the usefulness of IT, mainly in the domain of customer complaints monitoring. In their opinion, it is still unclear, if social and environmental management capabilities evolve dependently or not.

Traditionally the role of corporate IT Systems with regard to environmental impacts was often mentioned in the context of *Green IT*, focusing on the reduction of energy consumption of IT systems. In a more recent research field, *Green Information Systems*, the role of IT is seen in a broader context, focusing on transformation of business and information processes *through* IT [5,9].

Also Dao, Langella and Carbo [8] call for a bold new role of IT in sustainability beyond energy consumption reduction. Adapting a resource-based view, they argue that bundling HRM, SCM, and IT resources enable firms to develop sustainability capabilities. More specifically, they propose an integrated sustainability framework which sheds light on both internal and external drivers to improve current practices and develop long-term sustainability capabilities. They specifically highlight the need to include the whole supply chain.

Chen, Boudreau and Watson [7] suggest a conceptual model and propositions with regard to the roles of IS in the quest for ecological sustainability. They mainly deal with the potential of IS to increase eco-efficiency by automation and by providing information to stakeholders to facilitate learning processes. Both of these options ideally lead to transformations of business processes and accordingly, to increased ecologic sustainability.

Summing up, sustainability risks need to be managed across the supply chain. Literature suggests that IT plays an important role leveraging this process and furthermore supports inter-organizational learning.

UNDERSTANDING INFORMATION NEEDS IS THE KEY

Providing the right information sources is the key to manage sustainability risks appropriately. However, in many cases company information needs with regard to sustainability are not fulfilled. For example, managers often lack knowledge about second or later tier suppliers. Even if the information exists internally, it is often neither integrated nor structured as to be useful for sustainability analysis. Important data might be distributed over a large variety of different data silos and ERP systems. Scientifically this problem can be explained with the information subset model developed by Szyperski [24] and presented in Figure 1.

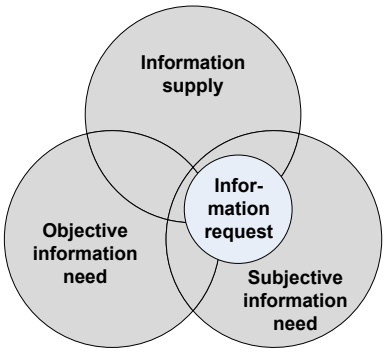

Figure 1: Information subset model based on Szyperski [24] in Becker et al. [3]

Skyperski defines four information sets: the information supply, the objective and the subjective information need as well as the information request. As depicted in Figure 1, the circles representing the different sets do not fully overlap in practice. In the ideal case, the information subsets should be as close as possible, meaning the supplied information should cover the information that users need and request.

As a consequence, developing an information system has to be footed on a profound understanding of information needs. Only then can the information system be designed to match the combined information need as closely as possible with a corresponding information supply [3].

APPROACH AND FRAMEWORK

This paper focuses on understanding the information needs of different stakeholders with regard to a sustainability risk management system. The resulting analysis serves as a starting point for the design of information resources necessary to fulfill the identified needs. The results of the analysis characterize the output of such a system. This focus is depicted in Figure 2.

In order to derive information needs for different stakeholder groups, a literature-based approach was used. The resulting compilation consists either of needs highlighted by literature for a specific stakeholder group or needs that were implicitly derived from literature. The list of information needs does not claim completeness, but attempts to highlight important elements that must be considered when designing a sustainability risk management system. Finally, the paper concludes with a characterizing overview of information needs, split into the different stakeholder groups.

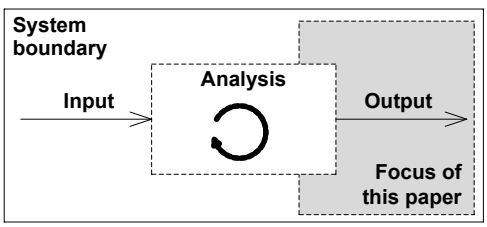

Figure 2: System boundaries and focus of discussion (author's compilation)

STAKEHOLDER INFORMATION NEEDS

Company internal stakeholder groups

Employees & labor unions

Generally, by transporting information from higher management levels downwards to employees, information systems can generate awareness on certain topics, which in turn can influence operational practices [7]. By making the information on environmental and social impacts of organizational activities accessible to employees, a sustainability risk management system can increase the salience of sustainability topics and foster the development of eco-friendly and social values in the organization, leading to more sustainable decisions and business practices [7].

Employees have different information needs when it comes to the visualization of sustainability risks. On the one hand, employees demand a confirmation that their employer is operating in an ethically responsible way. This is also important to attract talented future employees, who prefer to work in companies with high ethical standards [16]. A good overview about current sustainability issues and risks presented in a visually appealing way, can help to meet these information needs.

On the other hand, employees and moreover labor unions are interested in sustainability risks which relate to issues directly affecting themselves (e.g. worker protection, equality or health issues). Therefore it seems beneficial to provide an employee-specific view offering information about selected social aspects, which are directly related to their regions, organizational units and interest levels (detailed, general).

Management

For efficient risk management, management needs a comprehensive picture of the sustainability risks that endanger their company. However, an exhaustive list seems hardly possible and striving for completeness is a very time consuming task. Furthermore, the confidence that all risks have been covered will usually remain low [12]. Especially two dimensions, content and time, appear to affect completeness:

Content completeness is strongly influenced by the complexity that especially multinational companies face [29]. To achieve a comprehensive view, all steps of the production process need to be considered as sustainability starts with the product design and ends with the recycling activities [18,28]. This process does not stop company internally; also data from lower steps of the value and thus supply chain are needed. For example, the system for environmental monitoring along the value chain described by Carlson et al. allows for an exchange of data between supply chain partners [6]. Data exchange has to include a large number of different data items at each step to create a picture that is as complete as possible [25]. For suppliers also auditing, self assessments and supplier metadata regarding sustaina-

bility should be provided [13]. Furthermore, the content analysis should also include soft parameters [26].

Time completeness requires having the data from the past up to the present. This entails data availability in near real-time, which is fostered by the increasing availability of sensors or RFID systems deployed e.g. at production sites or logistics, (see Björk et al. or Verma, S. and Chaudhuri [4,27]). Moreover, it includes the ad-hoc visibility of incidents.

To achieve completeness, data might come from various sources, e.g. from suppliers, from NGOs, from company audits, from external organizations such as SEDEX, and all data needs to be finally integrated into a consistent view [14]. Furthermore, data needs to be linked to other functions of a company. For example risk management needs to be consistently integrated e.g. into procurement [29].

Besides, management has a general interest in respecting its data confidentiality standards. If, for example, sensitive data about supplier risk levels is handled, security concerns need to be respected. This claim gets even more critical, if information is exchanged between different organizations [2]. Another point highlighted by literature and definitely important for all consumers of a system, is the comprehensibility of the software. For management, comprehensible overviews and details are important. This can be realized in multiple ways. One can for example be a visually appealing map-based data presentation with a geographical information system (GIS; see [19]).

Company external stakeholder groups

Government

In general, governments are interested in the compliance of regulations and laws and therefore monitor companies' activities as well as their products. This assessment process can be leveraged by a near-real-time standardized information exchange between companies and regulatory bodies. An optimized information flow reduces the risk for companies (as problems are noticed early on) and generally increases the efficiency of the compliance framework. As governments aim for a complete picture, they need to link data from different supply chains to get a more complete picture [11]. This would be facilitated by an internationally standardized setting [29].

Public (incl. NGOs, investors, customers)

The public understanding of sustainability issues can be enhanced through information systems that distribute information more quickly, broadly and cheaply [7].

Media and NGOs use the web to publish information about environmental or social aspects in a fast and dynamic way. Furthermore, the public and foremost customers are strongly interested in any sustainability issues within the whole supply chain [29]. Companies need to respond to this development and provide information to various external stakeholders in an efficient and timely manner.

Significant information needs X..Fullly needed /..Partly needed		Information needs																					
		Scope			Sustainability		Content[1]			Temporal focus			Data attributes: Trigger		Granularity		Expected format		Confidentiality		
Area	Stakeholder group	Supply chain level	Company level	Sub-comp. level (reg., unit, …)	Environmental	Social	General risk data	Company's auditing approach	Product & part related risk data	Past data	Current data	(Near) real time data	On stakeholder request	Response to stakeholder input	Overview	Detailed	Standardized/Schema based	Unspecified	At company level	At supply chain level	Public
Internal	Employees & labor unions		X	X	/	X	X	/		/	X		X		X			X	X		
	Management	X	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X		
External	Governments	/	X	/	X	X	/	X	X	X	X	/	X			X	X		X		
	Public (incl. NGOs, investors, customers)	X	X	X	X	X	X	/	X	/	X		X		X	/		X			X
	Suppliers & partners	X	/		X	X	/	X	/	/	X	/	X	X		X	X			X	

Table 1: Overview of risk information needs by stakeholder group (authors' compilation; grey areas in content area indicate parts not addressed in the text)

Especially customers, but also other parties interested in a company like investors or media, have a need to be informed about sustainability-related performance and hence the risk level associated with a company in order to make more informed decisions. Sustainability performance is not only connected with the company, but also directly with the product [25]. Sustainability aware customers request information about the general sustainability related to a product or company. This information increasingly influences buying decisions. The system should provide a high-level overview for interested customers without revealing company internal details that might harm employees or company assets.

The increasing number of socially responsible investments indicates the rising importance of sustainability in the financial market [15]. With the introduction of the Dow Jones Sustainability Index, a global, rational index which measures the performance of investments into sustainably acting companies has been established [1]. This suggests that investors are interested into a transparent picture of important sustainability risks.

Another group to be considered are locals who are directly affected by the corporation's activities, like communities residing near production sites or in areas providing the resources (land, water, forest, …) to be used in production processes. To proactively sense possible conflicts or complaints, communication is an important matter. The system should therefore provide information to affected stakeholders specifically focused on a concrete regional area.

Supplier & partners

With regard to sustainability, an improved information flow including environmental and social aspects can result in a better understanding of inter-organizational sustainability matters and thereby lead to more sustainable decisions [8]. To enable this learning process it is important to establish data exchange in both ways along the supply chain. For an integrative sustainability risk management system, this calls for the requirement to provide individual views on the data for each supplier. Since a learning-process is an unstructured and rather unpredictable process, several layers, configuration and query options could help to adapt the information supply to the subjective information needs of suppliers.

Moreover, if focal companies require data from supplying companies, these suppliers will likely want to get feedback based on their data input. To ease this communication, data-models and communication protocols that facilitate the transaction will be important. For example Barrett, Strunjaš-Yoshikawa, and Bell proposed a data model to ease the exchange of life cycle data for emission calculations [2]. The same is likely to be true for cooperating partners. Furthermore, suppliers will be very much interested in the way they are monitored and thus have information needs about the rating process [29].

SUMMARY AND CONCLUSION

Although some companies already engage in stakeholder dialogues, stakeholder opinions, reactions and concerns are not integrated in a dynamic way into business considerations and especially into a risk management approach. Companies need tools and processes which support them to collect and visualize sustainability data in a fast and effective way, not only inside but also outside the company's borders.

Based on the outlines above, Table 1 summarizes the different risk information needs of multiple stakeholder groups. When not addressed in the text, elements of the table were estimated from the context. These are left for further discussion.

As highlighted, the different stakeholders and typically management have very broad and diverse information needs. A potential integrative sustainability risk system has to account for all of them as they define the scope of the system. Yet, given the amount of actors and needs, a prioritization of requirements seems necessary.

The information needs discussed here, specifically focus on the output side of a system. Research has to further explore requirements related to system internals, i.e. the analytics, and the data input required. Hence, Table 2 outlines the resulting research questions.

Research question	Description
Which data sources can be used to fulfill the information needs?	As information needs define the necessary information supply, different sources will be necessary to meet the needs posed by various stakeholders. These sources can be both, company-internal and external.
Which analytical modules are necessary to integrate and analyze the data to fulfill the information needs?	Data sources will not provide information that can be presented straight to stakeholders. Multiple sources need to be validated, disambiguated, conflicting data resolved, combined and aggregated in order to be convincing. For this purpose, sophisticated algorithms will be necessary that have to account for uncertainty.
How can sustainability risks be automatically assessed?	In order to automatically evaluate sustainability risks, a detailed understanding of completeness of environmental and social sustainability is necessary.
In which ways can the information be presented to meet the individual needs of various stakeholder groups?	In recent years various techniques for information presentation have been developed by multimedia scientists. Due to its special context and the possible large amount of information, advanced presentation techniques can help stakeholders to be able to use the information in an improved way.
How can the system be designed in order to ease integration into existing company software landscapes?	A sustainability risk system will be one element of a complete and integrated company IT landscape. It will exchange information with other systems using specific interfaces. Moreover, this landscape is constantly evolving and system design needs to take care of this in advance.

Table 2: Research questions

In this paper, the authors analyzed different information needs stated by stakeholders for an integrative sustainability risk management system. In subsequent research, these insights will be used as a starting point for the design of a prototypical implementation of a sustainability risk management system. In the future, the authors plan to contribute to the body of knowledge in the field of Enterprise Information Systems & Sustainability in essentially three areas: (1) Evaluation and development of different mechanisms for sustainability data collection (linked open data, crowdsourcing based approaches, sensing, text mining) (2) Advanced analytics for sustainability risk calculation (social focus) (3) Map-based data representation for improved stakeholder communication.

ACKNOWLEDGMENTS

The 2nd author of this paper is financially supported by the Vienna PhD School of informatics (http://www.informatik.tuwien.ac.at/teaching/phdschool).

REFERENCES

1. Balik, M. Nachhaltigkeitsmanagement: mit Sustainability Management durch Innovation und Verantwortung langfristig Werte schaffen. VDM, Verlag Dr. Müller, 2006.
2. Barrett, W.M., Strunjaš-Yoshikawa, S., and H Bell, J. Extension of computer-aided process engineering applications to environmental life cycle assessment and supply chain management. In Valentin Pleşu and Paul Şerban Agachi, ed., Computer Aided Chemical Engineering. Elsevier, 2007, 1187–1192.
3. Becker, J., Brelage, C., Dreiling, A., and Ribbert, M. Business process-driven information requirements engineering. Proceedings of the 2004 International Information Resource Management Association Conference (in Review), New Orleanse, LA, USA, (2004).
4. Björk, A., Erlandsson, M., Häkli, J., et al. Monitoring environmental performance of the forestry supply chain using RFID. Computers in Industry 62, 8–9 (2011), 830–841.
5. Boudreau, M.-C., Chen, A., and Huber, M. Green IS: Building sustainable business practices. Information Systems: A Global Text, (2008).
6. Carlson, R., Erixon, M., Forsberg, P., and Pålsson, A.-C. System for integrated business environmental information management. Advances in Environmental Research 5, 4 (2001), 369–375.
7. Chen, A.J.W., Boudreau, M.-C., and Watson, R.T. Information systems and ecological sustainability. Journal of Systems and Information Technology 10, 3 (2008), 186–201.
8. Dao, V., Langella, I., and Carbo, J. From green to sustainability: Information Technology and an integrated sustainability framework. The Journal of Strategic Information Systems 20, 1 (2011), 63–79.
9. Dedrick, J. Green IS: concepts and issues for information systems research. Communications of the Association for Information Systems 27, 1 (2010), 11.
10. Dyllick, T. and Hockerts, K. Beyond the business case for corporate sustainability. Business strategy and the environment 11, 2 (2002), 130–141.
11. Hofman, W. Supply Chain Visibility with Linked Open Data for Supply Chain Risk Analysis. Workshop on IT Innovations Enabling Seamless and Secure Supply Chains, (2011), 20–31.
12. Huang, L.G., Port, D., Wang, L., Xie, T., and Menzies, T. Text mining in supporting software systems risk assurance. Proceedings of the IEEE/ACM international conference on Automated software engineering, (2010), 163–166.
13. Klassen, R.D. and Vereecke, A. Social issues in supply chains: Capabilities link responsibility, risk (opportunity), and performance. International Journal of Production Economics 140, 1 (2012), 103–115.
14. Kogg, B. and Mont, O. Environmental and social responsibility in supply chains: The practise of choice and inter-organisational management. Ecological Economics 83, , 154–163.
15. Kraus, P. Die Auswirkung von Corporate Governance und Nachhaltigkeit auf den Unternehmenserfolg. BoD–Books on Demand, 2011.
16. Münstermann, M. Corporate Social Responsibility: Ausgestaltung und Steuerung von CSR-Aktivitäten. Springer DE, 2007.
17. Piotrowicz, W. and Cuthbertson, R. Sustainability - a new dimension in information systems evaluation. Journal of Enterprise Information Management 22, 5 (2009), 492–503.
18. Ramani, K., Ramanujan, D., Bernstein, W.Z., et al. Integrated Sustainable Life Cycle Design: A Review. Journal of Mechanical Design 132, 9 (2010), 091004.
19. Rao, N.H. A framework for implementing information and communication technologies in agricultural development in India. Technological Forecasting and Social Change 74, 4 (2007), 491–518.
20. Rockström, J., Steffen, W., Noone, K., et al. A safe operating space for humanity. Nature 461, 7263 (2009), 472–475.
21. Schaltegger, S., Windolph, S., and Harms, D. Corporate Sustainability Barometer–wie nachhaltig agieren Unternehmen in Deutschland? Centre for Sustainability Management der Leuphana Universität Lüne-

burg/PricewaterhouseCoopers, Lüneburg/Frankfurt aM. 2010.

22. Smith, L. The New North. Profile Books, 2012.
23. Srivastava, S.K. Green supply-chain management: A state-of-the-art literature review. International Journal of Management Reviews 9, 1 (2007), 53–80.
24. Szyperski, N. Informationsbedarf. Handwörterbuch der Organisation 2, (1980), 904–913.
25. Trienekens, J.H., Wognum, P.M., Beulens, A.J.M., and van der Vorst, J.G.A.J. Transparency in complex dynamic food supply chains. Advanced Engineering Informatics 26, 1 (2012), 55–65.
26. Vannieuwenhuyse, B., Gelders, L., and Pintelon, L. An online decision support system for transportation mode choice. Logistics Information Management 16, 2 (2003), 125–133.
27. Verma, S. and Chaudhuri, R. Creating Customer Satisfaction And Profitable Value Chain With E-commerce In Rural India: A case based approach. International Journal of Business Insights & Transformation 2, 1 (2009), 51–63.
28. Wang, H.-F. and Gupta, S.M. Green Supply Chain Management: Product Life Cycle Approach. McGraw-Hill Professional, 2011.
29. World Economic Forum. New Models for Addressing Supply Chain and Transport Risk. World Economic Forum, Cologny/Geneva, 2012.
30. How We Work with Business. WWF Canada. http://www.wwf.ca/about_us/business/index.cfm.