How Software Promotes the Integration of Sustainability in Business Process Management

Maren Stadtländer[1], Thorsten Schoormann[1], and Ralf Knackstedt[1]

[1] University of Hildesheim, Department of Information Systems and Enterprise Modelling, Hildesheim, Germany
{maren.stadtlnder,thorsten.schoormann,ralf.knackstedt}
@uni-hildesheim.de

Abstract. Business research and practice increasingly focus on integrating sustainability in organizations. To contribute to rising challenges related to the society and the environment, sustainability-driven concepts (e.g., environmental-friendly) have to be implemented in the daily business routines, and thus, need to be considered during the design of business processes in any organization. In this study, we conceptualize the field of Green Business Process Management (BPM) and use the derived concepts to classify supporting modelling tools and concrete software features. While our study indicates a lack of realization of the ecological and social sustainability in particular and a gap in supporting users during the redesign phase, there are software features that can potentially serve as a starting point to further incorporate sustainability in the design, implementation, and controlling of business processes.

Keywords: Green BPM, Classification, Tool Support, Software Feature.

1 Introduction

Due to complex challenges related to the environment (e.g., climate change) and our society (e.g., human equity) [1], sustainability has become of increasing interest in business research and practice [2, 3]. Facing these challenges, businesses need to transform themselves to allow changes in behaviour and practice as well as to fulfil new demands like being environmentally friendly [2, 4]. Therefore, novel and more sustainable business models need to be developed [5] that not only rethink separated aspects, but rather focus on radical innovations across entire businesses [6]. For implementing such new business models, it is important to align the daily, underlying business routines [7]. Therefore, on an operative level, approaches from business process management (BPM) come into play, contributing to the understanding, modelling, implementing, and optimizing business processes by, for instance, providing methods such as modelling techniques and (software) tools [8–10].

BPM is a widely used approach to develop or change organizational structures as well as increase awareness of business processes [11]. Since business processes are an essential aspect of organizations, it is necessary to properly consider sustainability-driven concepts during the design of such processes [12, 13]—it is assumed that this

14th International Conference on Wirtschaftsinformatik,
February 24-27, 2019, Siegen, Germany

will eventually lead to a more sustainable organization [14]. To design sustainable processes, an increasing amount of approaches for reducing energy or emissions in particular are proposed, which are typically discussed in the context of *Green BPM* [2, 15]. Green BPM takes a holistic view on the field and aims to respect sustainability across the entire lifecycle [16], for example, by integrating Green Business Process Patterns, Green Process Benchmarking, Key Ecological Indicators, or Energy-Aware Adaption (e.g., [17]). Corresponding modelling notations deal among other aspects with representing fuel or paper consuming activities [18], visualizing CO_2 footprints [19], or calculating energy flows [20] as well as support the representation of environmental impacts by integrating values and key factors for analysing the current state and optimization potential for reaching green goals [13, 15, 16]. To do so, these approaches often deal with adapting existing notations such as Business Process Model and Notation (BPMN) or Event Driven Process Chain (EPC) [16, 18, 21, 22]. Considering sustainability, according to existing literature in the field, also calls for changes to further parts of the six core elements of BPM, e.g., by using Sustainability Balanced Score Cards, adapting the process performance management to include sustainability factors, or drawing from Energy Informatics [17].

For contributing to sustainability in BPM and for applying such notations, following Recker's [23] statement that 'modelling with tools is easier', appropriate software tools need to be provided that fulfil new requirements [22]. However, although there is quite a large set of BPM software as well as different adaptions and extensions towards Green BPM, we currently lack matching these streams. To the best of our knowledge, only very few research studies (e.g., [24]) investigate some selected modelling software and compare it with criteria derived for BPM. Accordingly, this study is guided by the following key question: *How does current BPM software support the design, implementation, and monitoring of business processes in terms of economic, but primarily of ecological and social sustainability?*

For answering this question, as a first step, we conceptualized the field of Green BPM in order to derive types of adaptions, extensions, approaches, and criteria. Based on this conceptualization, we carried out an extensive software tool search and classified a selected subset of these tools. Afterwards, we analysed which software features are currently available and compared them to the derived concepts of Green BPM. Our contribution is a classification that helps academics and practitioners, for instance, to get an overview of available modelling software and to get insights on how to (re-)design current features (tool designer). Overall, we hope that our findings may also act as a starting point for more research on requirements for tools that support sustainability in businesses processes as they are important for any organization.

2 Software Tools for (Green) BPM

In this section, we outline the research background of our article in order to provide an overview of studies that already deal with conceptualizing or addressing both fields software tools for BPM and Green BPM in general.

Starting from a literature review summarizing the current state of Green BPM research [17], we identified an evaluation of supporting process modelling tools [24] and a comparative overview of process simulation tools for Green BPM [25].

Opitz et al. [24] chose BPMN as a suitable modelling language for monitoring energy efficiency KPIs as an instance of ecological process indicators and tested five of over 70 BPMN modelling tools against project-specific criteria. The highest-scoring software, ARIS Business Architect, was later used in three case studies and proved well-suited for Green BPM in the specific case of energy efficiency monitoring. The study, however, focused on the ecological dimension of sustainability, without considering social KPIs.

Lübbecke et al. [25] examined different tools for business process simulation and, upon identifying their limits, developed their own EPC-based approach for decision-making in Green BPM to support process simulation and optimization using an existing simulation tool (*Plant Simulation*) as well as energy consumption data from an external tool. To this purpose, they extended the functionality offered by the simulation tool using the built-in scripting language. However, they recognize the need for further research in order to make the data collection and modelling process easier and enable automated import of simulation data.

Riemer et al. [26] have conducted a review of BPM tools, analysing which functionality is used in order to support the (collaborative) modelling process. The tools for this review were discovered through an internet and literature search and underwent a filtering and classification process in which, starting from an initial set of criteria, each tool was evaluated. The criteria set evolved throughout this process by supplementing additional criteria and reclassifying already evaluated tools. The final set consisted of three subsets (process modelling, collaboration, and technical criteria), while the final list of evaluated software contained 11 process modelling tools. Drawing from their results, Riemer et al. [26] not only propose an extensive list of features in process modelling software focusing on collaborative modelling, but were also able to develop a high-level architecture of collaborative process modelling tool support.

3 Research Design

3.1 Conceptualizing Green BPM

As a first step, we applied a deductive approach to derive dimensions and characteristics from prior studies that are related to Green BPM. We initially focused on existing reviews and meta-analysis of Green BPM that already aim to summarize knowledge. To do so, we selected search items [27] and searched for the keywords *"green business process management"*, *"green BPM"*, and *"literature review"* in AISeL and Google Scholar (search was conducted in July 2018). By employing this search phrase, we identified 57 articles across both sources. These articles were evaluated by reading the title, abstract, and keywords. Articles that are not in the scope of this study were eliminated. Afterwards, we obtained seven articles that met our purpose of structuring different concepts of Green BPM [16, 17, 24, 28–31].

Next, we independently analysed the results to obtain fundamental concepts of Green BPM and consolidated the results to achieve a common understanding (Table 1). In the following stages, these concepts are used as a coding schema to identify features that should be implemented by software tools in the context of Green BPM.

Table 1. Consolidated concepts for Green BPM based on prior literature

Concept	*Description*	*Reference*
Notation adaptation	Adapting modelling notation elements (e.g., BPMN, UML, or EPC) for representing sustainability.	[17, 24, 28, 30, 31]
Notation extension	Extending modelling notations (e.g., adding new elements) for representing sustainability.	[17, 28, 30, 31]
Process calculation	Describing indicators and their (mathematical) relations in a formal way (e.g., to enable simulation).	[31, 32]
Process simulation	Simulating process parts and entire business process models for analysing sustainability.	[16, 17, 24]
Process optimization	Optimizing processes regarding their sustainable impact.	[30, 32]
Process benchmark	Benchmarking different processes in respect of sustainability.	[17, 29]
Process pattern	Adding patterns to apply existing knowledge to enhance processes towards sustainability.	[17, 31]
Process performance	Developed and/or adopted performance measurement methods to capture sustainable process performance.	[30]
Process indicator	Developing and analysing Green BPM indicators e.g.: *Ecological*: {energy, water, waste, resources, power usage, fuel, paper, oil, toxic} consumption; {CO_2, GHG, greenhouse, noise} emissions; recycling, air quality, renewable resources … *Social*: accidents, radiation, workforce size, health, safety, education, earnings, equity …	[17, 24, 28–32]
BPM Lifecycle Extension	Extending existing BPM lifecycles and frameworks to respect sustainability goals.	[28, 30]

3.2 Gathering BPM Software Tools

Due to the large number of available software tools for BPM, we decided to focus on tools using one specific process modelling language, namely, BPMN. Although further graphical languages such as EPC, UML, and Petri Nets exists, BPMN 2.0 is well-accepted in the context of BPM [33], and thus, selected in this study.

A Google search was conducted to reach a broad overview using combinations of the search items "*BPMN 2.0*", "*software*" (as well as the synonyms "*tool*" and "*program*"), and "*model*" (as well as derived terms such as "*modeling/modelling*").

Initially, after examining the first nine pages—that is, 90 individual web pages—an unevaluated list of 90 modelling tools was derived.[1]

After collecting the first results, each tool was examined. If a tool was no longer available but substituted with a new or updated version, the tool was replaced by the current software version. Tools that are part of a tool family, of which several tools allow for BPMN 2.0 modelling, were split accordingly. Software that no longer includes BPMN 2.0 modelling or was mistakenly marked as such was removed from the list. The list was cross-checked against a more extensive overview of modelling tools for various notations, leading to some additions.

The information on all tools was gathered from the software suppliers' websites and additional sources, such as product-related blogs (e.g., [34]) and studies [35, 36]. Due to financial and temporal constraints, the list for the analysis was narrowed down to 24 tools of which the majority is freely available. This choice was made because (1) academic modellers often use free software due to financial restrictions and higher perceived cost-effectiveness as well as (2) we would argue that especially (green) start-ups often lack the funds to acquire expensive software. For selection, the tools were grouped by the type of software (client, web-based, cloud-based, other, n. s.; though n. s. and cloud-based were excluded) and randomly selected in relation to the percentage of tools in each group. During the detailed analysis, *FujitsuRunMyProcesses* was removed as the current version does not support BPMN 2.0 anymore. Thus, only four shareware products remained.

3.3 Deriving Features for the Green BPM Concepts

For deriving software features, each tool was analysed regarding the concepts (cf. Section 3.1) in an inductive manner (i.e., empirically seeking for related software features). To do so, the modelling of a scenario—a simple artificial purchase and return process—guided this search, which was executed by the paper's main author. For modelling the scenario, the modeller had to carry out four main tasks, which attempt to cover all of the identified concepts: First, several sustainability performance indicators need to be included. Second, existing notation elements should be adapted and new elements need to be added. Third, the process should be monitored, simulated, automated, and analysed. Fourth, patterns and process optimization techniques need to be used. Thus, all defined concepts were covered by the case. Using the concept-based scenario, the supporting features were identified: if the software enabled fulfilling the concept—i.e., if it included a feature that could be used to model the new elements, performance indicators, or to monitor, simulate, or analyse the process etc.—the feature used was noted down. The features were accordingly clustered into groups (cf. Table 3, Section 4). On average, it took 20 minutes to examine each tool.

[1] Several institutions provide extensive lists of BPM software tools (e.g., Fraunhofer Institute or BPM&O GmbH). These lists were also included in our research.

4 Results

In Table 2, the results for each of the 23 software tools in our sample is summarized. For the classification, we particularly built on the conceptualization (cf. Section 3.1) and differentiated between the following five main dimensions:

- *Sustainability*—the first dimension differentiates between the common pillars of sustainability, namely, economic, ecological, and social (e.g., Triple Bottom Line), to indicate which type of sustainability is generally addressed by a software tool.
- *BPM lifecycle*—the second dimension makes use of the BPM phases from Dumas et al. [37] in order to visualize in which activity a software tool provides support.
- *Notation*—in the third dimension, we distinguish between adaptable (are notation elements modifiable?), extendable (can new notation elements be added?), and process patterns (included by the software manufacturer, community or modeller) to indicate how sustainability can be integrated in a modelling technique. The ability to modify or add notation elements may, among other things, indicate how much flexibility a user has to integrate their own ideas of how to depict sustainability.
- *Analysis*—the fourth dimension, for analysing business processes, differentiates between calculation (e.g., calculation of sustainability-specific variables), simulation (complete process simulation), animation (e.g., clicking through process paths), and comparison (of two or more process models, for example, through comparing simulation results). Especially simulation and comparison features may help a user to consider the ecological or social impact of their processes before implementation and enable them to compare different versions.
- *Performance indicators*—in the fifth dimension, we first aim to represent how indicators can be used by users and distinguish between usable as-is (e.g., if the tool offers an indicator), adoptable (an existing indicator may be repurposed), or extendable (new indicators may be added). This way, we may learn how difficult and/or time-consuming the use of sustainability indicators is in current tools. Further, we explored if software tools allow measuring specific ecological and social indicators found in the literature.

Moreover, to illustrate (1) how the sustainability-oriented concepts are realized by concrete software features and (2) how these are distributed in the tools (e.g., to indicate which features are often implemented as well as which features are rather neglected by software tools), we developed a morphological box (Table 3).

By using the morphological box, we aim to provide more detailed guidance on how features can be applied to contribute to sustainability in processes. Changing the colour of elements (here understood as process steps) and annotating processes (here understood as complete processes) represent easily implemented ways of highlighting (less) sustainable parts of the process. A user may, for example, decide to set the colour of process steps perceived as unsustainable to red, or add annotations (often in the form of virtual post-its or notes) describing social or ecological implications. More complex features such as calculating green KPIs during simulation or process execution, support sustainability monitoring and selecting a process with a better impact.

Table 2. Classification of software tools
(● full realization, ○ partial realization; * no graphical GUI, + simulation via third-party tools)

		Software tool/ Conceptualization	ADONIS Community Edition	AuraPortal Helium Modeler	Bonita BPM Studio Community	BPMN Visio Modeler	Camunda BPM Community Platform	Camunda Modeler	Eclipse BPMN2 Modeler+	Flowable*	GeneXus Business Process Modeler	HEFLO	Imixs-BPMN	Innovator for Business Analysts	jBPM	LucidChart	Modelio	ProcessHub	Prologics FireStart	QUAM	RunaWFE	Semtalk	ViFlow	W4 BPMN+ Web Modeler	yED Live
€		Freeware (F)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	-	●	-	-	●	●
€		Shareware (S)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	●	●	-	●	●	-	-
Sustainability		Ecological	○	-	○	○	-	-	-	○	-	-	-	○	○	-	○	-	●	n/a	○	-	○	-	-
Sustainability		Economic	●	●	○	○	-	-	-	○	-	-	-	●	●	-	○	-	●	n/a	○	-	○	-	-
Sustainability		Social	○	-	○	○	-	-	-	○	-	-	-	○	○	-	○	-	○	n/a	○	-	○	-	-
BPM Lifecycle		Identification	●	-	-	●	-	-	-	-	-	-	-	-	-	-	○	-	●	●	-	-	●	-	-
BPM Lifecycle		Discovery	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
BPM Lifecycle		Analysis	●	●	●	-	-	-	○	-	-	●	-	○	●	-	-	-	●	n/a	●	●	n/a	-	-
BPM Lifecycle		Redesign	-	-	-	-	-	-	-	-	-	-	-	-	-	-	●	-	-	n/a	-	-	-	-	-
BPM Lifecycle		Implementation	-	-	●	-	●	-	-	●	●	●	●	-	●	-	-	-	●	n/a	-	-	n/a	-	-
BPM Lifecycle		Monitoring	-	-	●	-	●	-	-	-	n/a	●	●	-	●	-	-	-	●	●	-	-	n/a	-	-
BPM Lifecycle		Extendable	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	n/a	-	-	-	-	-
Notation		Adapt	-	-	-	-	-	-	-	-	-	-	●	-	-	-	-	-	-	n/a	-	-	-	-	-
Notation		Extend	●	-	●	●	-	-	-	-	-	-	-	○	○	●	●	-	●	●	○	-	○	-	●
Notation		Process pattern	-	-	-	-	-	-	●	-	-	-	●	-	-	-	●	-	-	n/a	-	-	-	-	-
Analysis		Calculation	●	●	●	-	-	-	-	-	-	-	-	●	●	-	-	-	○	n/a	●	-	○	-	-
Analysis		Simulation	●	●	-	-	-	-	○	-	-	●	-	○	●	-	-	-	-	n/a	●	●	n/a	-	-
Analysis		Animation	-	-	-	-	-	-	-	-	-	-	-	●	-	-	-	-	-	n/a	-	-	-	●	-
Analysis		Comparison	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	●	n/a	-	-	-	-	-
Performance Indicator	Use	Useable	●	●	-	-	-	-	-	-	-	-	-	-	●	-	-	-	●	n/a	-	-	○	-	-
Performance Indicator	Use	Adoptable	●	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	●	n/a	-	-	-	-	-
Performance Indicator	Use	Extendable	-	-	●	●	-	-	-	-	-	-	-	●	●	-	-	-	●	○	○	-	●	-	-
Performance Indicator	Ecological	Paper con.	○	-	○	○	-	-	-	○	-	-	-	-	○	-	-	-	○	n/a	○	-	○	-	-
Performance Indicator	Ecological	Energy con.	○	-	○	○	-	-	-	○	-	-	-	-	○	-	-	-	○	n/a	○	-	○	-	-
Performance Indicator	Ecological	CO_2 emission	○	-	○	○	-	-	-	○	-	-	-	-	○	-	-	-	○	n/a	○	-	○	-	-
Performance Indicator	Ecological	Other	○	-	○	○	-	-	-	○	-	-	-	○	○	-	-	-	●	n/a	○	-	○	-	-
Performance Indicator	Social	Employee health	○	-	○	○	-	-	-	○	-	-	-	-	○	-	-	-	○	n/a	○	-	○	-	-
Performance Indicator	Social	Employee equity	○	-	○	○	-	-	-	○	-	-	-	-	○	-	-	-	○	n/a	○	-	○	-	-
Performance Indicator	Social	Employee security	○	-	○	○	-	-	-	○	-	-	-	-	○	-	-	-	○	n/a	○	-	○	-	-
Performance Indicator	Social	Other	○	-	○	○	-	-	-	○	-	-	-	○	○	-	-	-	○	n/a	○	-	○	-	-

Table 3. Features for implementing the Green BPM-concepts

Concept	*Software featuress*				
Notation adaptation	changing colour of elements (10/23)	adapting BPMN tasks/events to trigger automated reports (1/23)	linking elements with other processes/other resources[1] (6/23)	annotating[1] (12/23)	
Notation extension	adding new elements (4/23)	adding new business objects/process variables (4/23)	adapting elements from elements of other notations (7/23)	adding views (1/23)	
Process calculation	calculating via simulation (5/23)	calculating during process execution (3/23)	generating reports (2/23)	calculating single variables (3/23)	calculating all variables (5/23)
Process simulation	using own simulation engine (7/23)	using external simulation plugin (1/23)	simulating to generate KPIs/ variables (6/23)	checking correctness via simulation[1] (1+/23)[2]	simulating reports (1/23)
Process optimization	using built-in comparison (1/23)	using built-in improvement feature (1/23)	importing customized process pattern catalogues (1/23)		
Process benchmark	using built-in comparison (1/23)	using external comparison (0/23)			
Process indicator	using implemented KPIs (5/23)	extending a set of business/process variables/KPIs: calculable (6/23)	extending a set of business/process variables/KPIs: non-calculable (2/23)	adopting risk models (3/23)	

Legend: 0 | 1-4 | 5-8 | 9-12 | >12

5 Discussion and Implications

5.1 Describing the Current State of Software Tools for BPMN

Based on our analysis, the following main observations emerged: First, while most tools in our sample focus on *discovery* and *analysis*, the phase of *redesign* in the BPM lifecycle is rather neglected in current BPMN software, which complicates revising existing business processes towards sustainability. For instance, users may compare two versions of a process diagram—manually or by comparing simulation results—but only one software offers an option for redesign by allowing to include a library of process patterns. The process patterns included in other tools only consist of general workflow patterns, intended rather for saving time while modelling than for redesign.

Second, for visualization and increasing the awareness of sustainability-oriented aspects in current business processes, a number of tools allow applying elements of other notations or self-created elements. Extending the notation can be carried out by modelling the new elements in the BMPN 2.0 diagram itself, or by referencing between processes or process elements and elements within diagrams of other types. However, repurposing or creating elements defined by single users and not the software provider

1 Adapted from Riemer et al. [26].
2 As this feature was not part of our analysis criteria and the modelled example process, we cannot give the exact number of tools implementing it.

themselves, would most likely not be shared with a broader community of business process modellers, thus encouraging isolated (and heterogeneous) application.

Third, sustainability indicators are rarely implemented in our sample, with economic indicators (e.g., costs and time) outweighing ecological and social ones. This is surprising because in contrast to the tools research exists that already explores, for example, key ecological indicators in the context of BPM (e.g., [16]). The tools that contain indicators for costs use pre-set variables, often dubbed as 'resource KPI', 'KPI', or 'business variable'. Only *Prologics FireStart* includes one pre-set ecological indicator ('Umweltindex') in the form of a (unspecified) scale from 1 to 10, which leaves the interpretation open for users. Some other tools allow adding own indicators by using variables referencing risk model elements (including ecological, economic, and social risks, as defined by the modeller). In some cases, where no indicators for social or ecological sustainability exist by default, features are incorporated that may be repurposed to act as indicators: most notably risk models, user-created process variables, objects, or KPIs, or analysable extension fields. These would need to be explicitly created and adapted by the modeller. While this adaptation and repurposing enables, for example, the highlighting of fuel and paper consuming activities [18] or calculation of energy flows [20] as described in the literature, the lack of pre-installed extensions and examples for sustainability indicators may hinder reflection of ecological or social aspects within the modelling process.

5.2 Deriving a Preliminary Set of Requirements for BPM Software Tools

Based on our findings from exploring a sample of current software tools for BPM as well as comparing them with sustainability-oriented concepts that are grounded in previous literature, we aim to specify a first set of (new) requirements for such tools:

- *Integrated catalogue of Green BP Patterns*—Implementing a pre-installed catalogue of green patterns in order to support users to, for example, identify potential for improvement of current processes as well as get ideas on how to improve current deficits in terms of ecological and social sustainability (e.g., [25, 27, 38]).
- *Sustainability-oriented performance indicators*—Including pre-installed indicators for ecological and social sustainability in order to facilitate, for example, the measurement of business process outcomes (e.g., as researched in [17, 24, 28–32]).
- *Comparison of process variants*—Providing feature(s) for comparing the ecological, economic, and social impact of different processes or process variants in order to support the users in making informed decisions for the redesign.
- *Data import*—Implementing interfaces for (automatic) import of data related to sustainability-oriented indicators, for instance from sources like energy monitoring systems, to support both process simulation and real-time monitoring.
- *Sustainability-driven constructs*—Providing notations to visualize ecological (e.g., resource consumption) and social aspects (e.g., workplace conditions) in processes.

Of course, this set of requirements for software tools supporting Green GPM needs to be evaluated in future steps, for example, by building prototypes that instantiate derived requirements and demonstrate the utility of them (e.g., [39]).

6 Conclusion

In this study, we first conceptualized Green BPM and classified a sample of 23 existing BPMN 2.0 software tools in order to analyse the degree of satisfying the needs of Green BPM. Our results have yielded gaps in the support of Green BPM, especially in terms of social and ecological sustainability. Based on our results, we formulated a first set of requirements for such a class of software tools that need to be evaluated in future research. The analysis may help users who want to focus on the sustainability of their processes over the course of the BPM lifecycle to get an overview of suitable modelling software or how to reuse certain existing features for this purpose. Furthermore, it offers a guidance for software designers and researchers on where to begin enhancing existing software for Green BPM or designing altogether more sustainable modelling software.

Although we derived helpful insights for the field of Green BPM, this study is not free of limitations. First, the analysis mostly covers freeware tools, which may have a limited range of features compared to shareware software. Nevertheless, we aimed to select a representative set of tools as well as would argue that, for instance, start-ups with limited financial resources addressing sustainability might need freeware tools to support the operationalization of their ideas. Second, although we specified relevant concepts that should be implemented in software by reviewing previous literature, there might be more aspects that need to be considered in such tools. Third, the identification of corresponding features is based on own interpretations and decisions, which also have limitations (e.g., other researchers might identify more software features).

In future research, we plan to expand and evaluate the list of modelling software as well as the preliminary set of requirements. Using our analysis as a first step, it is now possible to generate guidelines for designing and developing BPM software that helps users examine ecological and social aspects and to examine the potential and necessity of implementing further sustainability indicators (e.g., as suggested by the Global Reporting Initiative). This is a necessary step in order to introduce a proactive consideration of multidimensional sustainability into the routine of organizations.

References

1. Brundtland, G.H.: World Commission on Environment and Development: Our common future. Oxford: Oxford University Press (1987)
2. Brocke, J. vom, Seidel, S., Recker, J.: Green Business Process Management: Towards the Sustainable Enterprise. Springer Science & Business Media (2012)
3. Melville, N.P.: Information Systems Innovation for Environmental Sustainability. MISQ 34, 1–21 (2010)
4. Hanelt, A., Busse, S., Kolbe, L.M.: Driving business transformation toward sustainability: exploring the impact of supporting IS on the performance contribution of eco-innovations. Inf. Syst. J. 27, 463–502 (2017)
5. Schaltegger, S., Freund, F.L., Hansen, E.G.: Business cases for sustainability: the role of business model innovation for corporate sustainability. Int. J. Innov. Sustain. Dev. 6, 95 (2012)

6. Nidumolu, R., Prahalad, C.K., Rangaswami, M.R.: Why Sustainability Is Now the Key Driver of Innovation. Harv. Bus. Rev. (2009)
7. Al-Debi, M.M., El-Haddadeh, R., Avison, D.: Defining the business model in the new world of digital business. In: Proc. of the Americas Conference on Information Systems, Toronto, Canada (2008)
8. Hammer, M.: What is Business Process Management? In: Brocke, J. vom and Rosemann, M. (eds.) Handbook on Business Process Management 1. pp. 3–16. Springer Berlin Heidelberg (2010)
9. Rosemann, M., De Bruin, T.: Application of a holistic model for determining BPM maturity. BP Trends. 1–21 (2005)
10. Scheer, A.-W., Brabänder, E.: The Process of Business Process Management. In: vom Brocke, J. and Rosemann, M. (eds.) Handbook on Business Process Management 2. pp. 239–265. Springer Berlin Heidelberg (2010)
11. Rosemann, M.: Potential pitfalls of process modeling: part A. Bus. Process Manag. J. 12, 249–254 (2006)
12. Loos, P., Nebel, W., Marx Gómez, J., Hasan, H., Watson, R.T., vom Brocke, J., Seidel, S., Recker, J.: Green IT: A Matter of Business and Information Systems Engineering? Bus. Inf. Syst. Eng. 3, 245–252 (2011)
13. Seidel, S., vom Brocke, J., Recker, J.C.: Call for action: investigating the role of business process management in green IS. In: Hasan, H. and Dwyer, C. (eds.) Sprouts: Working Papers on Information Systems. AIS, Saint Louis, Missouri (2011)
14. Levina, O.: Exploring the Role of Business Process Management in Sustainability Initiatives. In: Proc. of the Mediterranean Conference on Information Systems, Samos, Greece (2015)
15. Meyer, J., Teuteberg, F.: Nachhaltiges Geschäftsprozessmanagement–Status Quo und Forschungsagenda. In: Proc. of the Multikonferenz der Wirtschaftsinformatik, pp. 1515–1530. Braunschweig, Germany (2012)
16. Opitz, N., Krüp, H., Kolbe, L.M.: Environmentally Sustainable Business Process Management-Developing a Green BPM Readiness Model. In: Proc. of the Pacific Asian Conference on Information Systems (2014)
17. Maciel, J.C.: The Core Capabilities of Green Business Process Management–A Literature Review. In: Proc. of the Wirtschaftsinformatik, pp. 1526–1537. St. Gallen, CH (2017)
18. Recker, J., Rosemann, M., Hjalmarsson, A., Lind, M.: Modeling and Analyzing the Carbon Footprint of Business Processes. In: vom Brocke, J., Seidel, S., and Recker, J. (eds.) Green Business Process Management, pp. 93–109. Springer Berlin Heidelberg (2012)
19. Houy, C., Reiter, M., Fettke, P., Loos, P., Hoesch-Klohe, K., Ghose, A.: Advancing Business Process Technology for Humanity: Opportunities and Challenges of Green BPM for Sustainable Business Activities. In: Brocke, J. vom, Seidel, S., and Recker, J. (eds.) Green Business Process Management, pp. 75–92. Springer Berlin Heidelberg (2012)
20. Hoesch-Klohe, K., Ghose, A.: Carbon-Aware Business Process Design in Abnoba. In: Maglio, P.P., Weske, M., Yang, J., and Fantinato, M. (eds.) Service-Oriented Computing, pp. 551–556. Springer Berlin Heidelberg, Berlin, Heidelberg (2010)
21. von Ahsen, A.: Qualitäts-und umweltorientierte Ausgestaltung von Führungs-und Leistungsprozessen. Integriertes Qualitäts-und Umweltmanagement: Mehrdimensionale Modellierung und Umsetzung in der deutschen Automobilindustrie (2006)
22. Houy, C., Reiter, M., Fettke, P., Loos, P.: Towards Green BPM – Sustainability and Resource Efficiency through Business Process Management. In: Business Process Management Workshops, pp. 501–510. Springer, Berlin, Heidelberg (2010)

23. Recker, J.: “Modeling with tools is easier, believe me”—The effects of tool functionality on modeling grammar usage beliefs. Inf. Sys. 37, 213–226 (2012)
24. Opitz, N., Erek, K., Langkau, T., Kolbe, L., Zarnekow, R.: Kick-starting Green Business Process Management–Suitable Modeling Languages and Key Processes for Green Perfomance Mesaurement. In: Proc. of the American Conference on Information Systems. Seattle, USA (2012)
25. Lübbecke, P., Reiter, M., Fettke, P., Loos, P.: Simulation-Based Decision Support for the Reduction of the Energy Consumption of Complex Business Processes. In: Proc. of the Hawaii International Conference on System Science, pp. 866–875. IEEE (2015)
26. Riemer, K., Holler, J., Indulska, M.: Collaborative process modelling-tool analysis and design implications. In: Proc. of the European Conference on Information Systems, p. 39. Helsinki, Finland (2011)
27. Schoormann, T., Behrens, D., Fellmann, M., Knackstedt, R.: <<Sorry, too much Information>> Design Principles for Supporting Rigorous Search Strategies in Literature Reviews. In: Proc. of the IEEE International Conference on Business Informatics. IEEE, Vienna, Austria (2018)
28. Stolze, C., Semmler, G., Thomas, O.: Sustainability in business process management research–a literature review. In: Proc. of the American Conference on Information Systems. Seattle, USA (2012)
29. Gräuler, M., Teuteberg, F.: Experimental Evaluation of a Process Benchmarking Tool in a Green Business Process Management Context. In: Proc. of the Wirtschaftsinformatik. Leipzig, Germany (2013)
30. Gohar, S.R., Indulska, M.: Business Process Management: Saving the Planet? In: Proc. of the Australasian Conference on Information Systems, pp. 1–14. Adelaide, Australia (2015)
31. Schoormann, T., Behrens, D., Knackstedt, R.: Sustainability in Business Process Models: A Taxonomy-Driven Approach to Synthesize Knowledge and Structure the Field. In: Proc. of the International Conference on Information Systems. Seoul, Korea (2017)
32. Opitz, N., Krüp, H., Kolbe, L.M.: Green Business Process Management -- A Definition and Research Framework. In: Proc. of the Hawaii International Conference on System Science, pp. 3808–3817. IEEE, Waikoloa, HI, USA (2014)
33. Harmon, P.: The state of business process management 2016. Bus. Proc. Trends (2016)
34. Hesse, M.: BPMN Tool Matrix, https://bpmnmatrix.github.io/ (Accessed: 22.09.2018)
35. BPM Toolmarktmonitor: Software für das unternehmensweite Prozessmanagement, https://bpm-expo.com/publikationen/software-fuer-das-unternehmensweite-prozessmanagement/ (Accessed: 22.09.2018)
36. Drawehn, J., Kochanowski, M., Kötter, F.: Business Process Management Tools 2014. Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO, Stuttgart, Germany
37. Dumas, M., La Rosa, M., Mendling, J., Reijers, H.A.: Fundamentals of Business Process Management. Springer Berlin Heidelberg (2013)
38. Nowak, A., Leymann, F., Schleicher, D., Schumm, D., Wagner, S.: Green Business Process Patterns. In: Proc. of the 18th Conference on Pattern Languages of Programs. pp. 6:1–6:10. ACM, New York, NY, USA (2011)
39. Peffers, K., Rothenberger, M., Tuunanen, T., Vaezi, R.: Design Science Research Evaluation. In: Design Science Research in Information Systems. Advances in Theory and Practice, pp. 398–410. Springer Berlin Heidelberg (2012)