A systematic review of Green Business Process Management

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Abstract

Purpose – Green Business Process Management (BPM) focusses on the ecological impact of business processes. Although it is an emerging field, different attitudes exist towards the discipline's name, the objectives and the approaches to realise them. By means of a systematic literature review, the purpose of this paper is to arrive at a common understanding of the discipline for successful development.

Design/methodology/approach – The review methodology relies on a hermeneutic framework which integrates the search, analysis and interpretation of the literature. The sample is used in a text analysis to find an appropriate definition (*RQ1*), a bibliometric analysis to give insights in current Green BPM contributions (*RQ2*) and a content analysis to present differences with conventional BPM (*RQ3*).

Findings – Green BPM follows a similar development as conventional BPM, namely from a more technical perspective to also including the managerial perspective. More research is required that goes beyond the traditional business process lifecycle.

Originality/value – The research questions generated a comprehensive overview about application domains and research topics, which in turn can deliver benefits for both research and practitioner-related communities. Researchers identify future research avenues, while practitioners find appropriate Green BPM techniques for their domain.

Keywords Environmental sustainability, Systematic literature review, Green IS, BPM capabilities, Green BPM

Paper type Literature review

1. Introduction

In recent years, the optimisation of operations for ecological objectives has gained importance. Business process management (BPM), which refers to "concepts, methods, and techniques that support the design, configuration, enactment, evaluation, and administration of business processes" (Weske, 2012, p. 5), is a key starting point. BPM's optimisation objectives typically refer to cost, quality, time and flexibility (Reijers and Liman Mansar, 2005). Recently, however, researchers increasingly advocate to extend the scope of conventional BPM (Nowak, Leymann and Schumm, 2011; Nowak, Leymann, Schumm and Wetzstein, 2011) with an environmental sustainability dimension, i.e. Green BPM (Seidel *et al.*, 2011).

In general, BPM relies on three major process traditions: the quality control tradition, the business management tradition and the information systems (IS) tradition. Currently, the tendency is that these three traditions are merging into a more comprehensive BPM approach (Harmon, 2015). However, the research field of Green BPM is currently dominated by Green IS, i.e. the discipline that examines the possibilities of information technology-based systems to cope with environmental problems (SIGGreen, 2015). Therefore, our study targets a comprehensive Green BPM approach which incorporates also other relevant but still under-investigated research areas.

Although an emerging field, Green BPM suffers from incertitude about the current state. For instance, scholars refer to "Green BPM" (Jakobi *et al.*, 2016) as well as "Sustainable BPM" (Ahmed and Sundaram, 2012). Some researchers solely focus on the reduction of carbon emissions in business processes (Ghose *et al.*, 2009), while others aim to reduce all environmentally harmful effects of organisational activities (Seidel *et al.*, 2011). Finally, Green BPM can also be seen as a general management approach (Kuppusamy and Gharleghi, 2015) while other contributions refer to an extension of existing BPM techniques (Nowak, Leymann

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and Schumm, 2011; Nowak, Leymann, Schumm and Wetzstein, 2011) and/or a central role for IS (Opitz *et al.*, 2014b). These different attitudes towards the discipline's name, the objectives and approaches to realise them are not contributing to a durable development of the research field. Instead, the research community should first have a common understanding of the discipline for successful development (Baskerville and Myers, 2002).

Webster and Watson (2002) argue that an effective literature review advances knowledge. "It facilitates theory development, closes areas where a plethora of research exists, and uncovers areas where research is needed" (Webster and Watson, 2002, p. xiii). Our review methodology relies on a hermeneutic framework presented by Boell and Cecez-Kecmanovic (2014). In line with the framework, we developed three research questions:

RQ1. What is a valid definition for Green BPM?

RQ2. What is the current state of Green BPM research?

RQ3. What are the differences between Green BPM and conventional BPM?

For *RQ1*, a text analysis is conducted on different Green BPM definitions. We present the differences with sustainable BPM, environmental sustainability contributions related to the underlying BPM traditions (e.g. Green IS) and conventional BPM. For *RQ2*, a bibliometric analysis is conducted to examine the publication type and geographical distribution of authorship. As a result, we encourage participation of currently missing but relevant research types. Finally, *RQ3* deepens the differences with conventional BPM and investigates the current scope of Green BPM by means of a content analysis. This results in future research directions on the body of theory and knowledge.

This research in the Green BPM field has social, business and academic purposes. As the effects of environmental degradation concern the entire society, industry should take responsibility. Green BPM research will help businesses make environmental considerations since Green BPM methods and techniques can be used by practitioners to environmentally optimise processes. From an academic point of view, we present a classification framework for Green BPM that researchers can use as a research agenda. Simultaneously, it can be used by practitioners as they can check if the techniques are relevant for them to deliver practically useful results.

This paper continues with the theoretical background (Section 2). Next, the methodology is detailed in Section 3. The results are given in Section 4 (*RQ1*), Section 5 (*RQ2*) and Section 6 (*RQ3*). The discussion is presented in Section 7, followed by concluding comments (Section 8).

2. Theoretical background

2.1 Foundations of Green BPM

The concept of sustainability (Brundtland, 1987) introduced environmental considerations into economic sciences. The Triple Bottom Line (Elkington, 1997) distinguished three dimensions of sustainability, i.e. economic, social and environmental. The IS community acknowledges the importance of environmental sustainability and states that the IS profession can provide critical knowledge to tackle the challenge of environmental deterioration (SIGGreen, 2015).

In addition to Green IS, a crucial role for process-centred techniques is acknowledged (Lübbecke *et al.*, 2016a; Opitz *et al.*, 2014a, b; Seidel *et al.*, 2011). In recent years, this Green BPM approach gained momentum for practice and research (Gohar and Indulska, 2015; Maciel, 2017; Opitz *et al.*, 2014a, b; Stolze *et al.*, 2012). Both disciplines are related but Green BPM, as opposed to Green IS, has a main focus on process change that goes beyond IT applications. In essence, this difference is due to the three major process traditions underlying BPM (Harmon, 2015). Table I gives an overview of the different traditions. For a profound discussion, we refer to Harmon (2015).

Process improvements are often represented by a business process lifecycle (BPL) involving different consecutive and iterative phases, i.e. originating from the established plan-do-check-act cycle (Deming, 1986). Initially, BPM focussed rather on technical capabilities such as process modelling, deployment and optimisation (Dumas *et al.*, 2013). These are mainly extracted from the quality control and IS tradition. Afterwards, also management capabilities gained importance (Weske, 2012). Finally, authors started examining organisational capabilities such as culture and structure (McCormack and Johnson, 2001; vom Brocke and Rosemann, 2014). These capability areas also originate from the Business Management tradition and support process improvements.

2.2 Classification frameworks for Green BPM

Being an emerging research field, Green BPM' underpinning is still missing. Intuitively, a well-accepted classification framework in the field of BPM could serve as a starting point for theory development. In our search for a holistic BPM framework, we looked at governance frameworks (e.g. COBIT), performance metrics (e.g. Balanced Scorecard) and measurement models (e.g. maturity models). Particularly, business process maturity models (BPMM) seem to be appropriate candidates because they help organisations in developing BPM strategies and roadmaps to guide their ongoing process efforts. Therefore, as companies have a wide variety of activities, a BPMM should cover all critical success factors in BPM. We make the proposition that these factors can also be used to evaluate the scope of Green BPM. More specifically, the question could be raised whether all critical capabilities for business processes are covered in a Green BPM context. Moreover, it allows a comparison between Green BPM and conventional BPM methods and techniques.

In the last decade, BPM researchers and practitioners have developed a long list of BPMMs with varied focus and depth (Hammer, 2007; McCormack and Johnson, 2001; OMG, 2008; Rosemann and de Bruin, 2005). However, only a limited set of BPMMs has been verified by sufficient empirical research (Tarhan *et al.*, 2016). To evaluate the scope of Green BPM, we rely on the conceptual framework presented by Van Looy *et al.* (2014). This meta-framework draws on theories regarding the traditional BPL and multiple recognised organisation management theories. The comprehensiveness of this framework was validated by mapping 69 BPMMs to the identified capability areas (Van Looy *et al.*, 2014). Being a meta-framework, its completeness and correctness of the presented critical success factors are better guaranteed.

Table II presents an overview of the capability areas, combined with the process change traditions, the categories of our evaluation model and the proposed translation to a Green BPM context. The capabilities for "process modelling", "process deployment" and "process optimisation" are grouped in the first category, called "BPL" (Deming, 1986; Dumas *et al.*, 2013). These rather technical capability areas are mainly extracted from the IS and quality control tradition. The second category consists of the first three capabilities extended with a "process management" capability area (Weske, 2012), and is referred

Business process management		
Quality control	Business management	Information systems
Taylor's work simplification Quality movement	Overall firm performance	Process reengineering application-based
TQM	Porter's value chain	Process modelling tools
Six Sigma	Balanced scorecard	Enterprise resource planning applications
Lean		
Capability maturity models		Business rules

Table I. An overview of the different approaches to business process change, including illustrative examples

Main traditions			Capability areas	Evaluation categories			Translation to a Green BPM context
Quality Control		Information Systems	(1) Process modelling (2) Process deployment (3) Process optimisation	BPL	BPM	BPO	This category groups research on making the business process lifecycle environmentally sustainable. It comprises methods and IT for the design, analysis, implementation and enactment, measurement and control, evaluation and improvement of business processes for environmental objectives
	Business Management		(4) Process management				This category extends the first category with the daily management of environmentally sustainable business processes, including the required roles and responsibilities with corresponding skills and training. It also involves linking green process goals to the organisational strategy and the relationships with customers, suppliers and other stakeholders
			(5) Process-oriented culture (6) Process-oriented structure				This category extends the first two categories with values that favour environmentally sustainable business processes and their translation into attitudes and behaviours. It requires appraisals and rewards that consider green process results and top management commitment. It also comprises specific organisational bodies to coordinate the management of all environmentally sustainable business processes within an organisation

Table II.
An overview of the main process change traditions, capability areas proposed by Van Looy *et al.* (2014), evaluation categories in this study and translation to a Green BPM context

to as "BPM." This capability area mainly relies on the quality control and business management tradition. The third category, "business process orientation" (BPO), adds the remaining capabilities for a "process-oriented culture" and "process-oriented structure." They are mainly based on the business management tradition (McCormack and Johnson, 2001). By combining the process traditions and the capability areas, we present an integrated classification framework. We are aware that exceptions exist, e.g. the use of information technology for management.

3. Methodology

Our methodology relies on a hermeneutic framework for reviews (Boell and Cecez-Kecmanovic, 2014) and integrates the search, analysis and interpretation of the literature. Figure 1 presents the framework applied to our study.

We iteratively ran through Circle 1 (i.e. search and acquisition) and Circle 2 (i.e. analysis and interpretation). We started with an initial search in several databases, resulting in 20 papers related to Green BPM and different terms related to the Green BPM field. Based on these terms, we developed a search string that was queried in seven leading academic databases (i.e. Web of Science, ScienceDirect, Emerald Insight, EBSCOhost Research Databases,

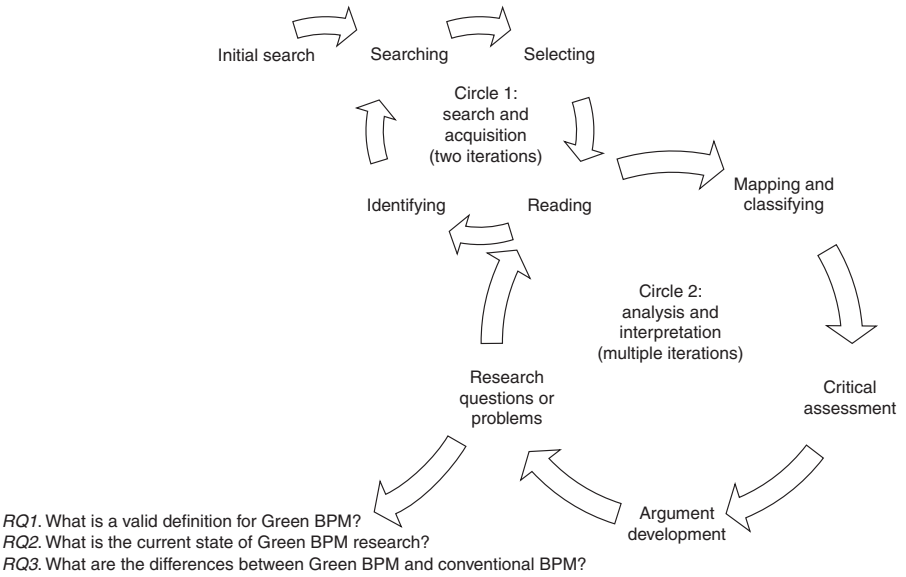


Figure 1. Hermeneutic framework for literature reviews (Boell and Cecez-Kecmanovic, 2014) applied to our study

IEEE Xplore Digital Library, Springer and AISeL). In total, 147 results were generated from the search string that combined the four key terms "Green Business Process Management", "Green BPM", "Sustainable Business Process Management" and "Sustainable BPM" with an OR operator. After removing duplicates, 70 papers were investigated on their relevance. We decided to limit our sample to those with a main focus on Green BPM, i.e. if they could be related to the critical BPM capabilities presented by Van Looy *et al.* (2014) (Table II). After investigation of the title, keywords, abstract and introduction, 45 out of 70 articles were selected as relevant. Next, the 45 primary articles were read and additional publications were detected based on citations. This resulted in 164 papers, from which 72 articles remained after removing duplicates.

Next, we re-started our first cycle with a search for those articles identified by citations. In total, 11 additional articles focussing on Green BPM were selected as relevant. We repeated the "read" and "identify" phase, but no new Green BPM articles were found. We concluded that two iterations of the "search and acquisition" circle were sufficient to collect the sample. Our initial review was conducted during January 2018. We then updated the review in January 2019 for any articles that had appeared in the last year, namely four additional papers. Thus, the final sample for our research consists of 60 articles (shown in Table AI with unique IDs).

Although chronologically described above, both research circles were intertwined since they build on each other in a recursive manner. The role and relevance of literature searches (i.e. Circle 1) is part of the broader process of literature understanding (i.e. Circle 2). The second circle includes specific phases that facilitate an understanding. Against this background, the need for more concrete research questions (*RQ1–RQ3*) was developed. From multiple iterations, we identified several interpretations of Green BPM. Therefore, *RQ1* aims at a common understanding among researchers. Concerning *RQ2*, we noticed different ways of dissemination and researchers involved, and intend to encourage participation of currently missing but relevant research types. Similarly, we observed that the comprehensiveness of Green BPM and the differences with conventional BPM varies. Hence, for *RQ3*, we evaluated the sample against the critical capabilities for business processes of Table II.

4. Results for *RQ1*

4.1 Analysis of explicit and implicit definitions

With regard to a common understanding of the field, we identified three problems to address the differences between Green BPM and sustainable BPM, environmental sustainability contributions related to the underlying BPM traditions and conventional BPM. We screened all 60 papers and found both explicit and implicit definitions. With implicit, we refer to indirectly extracted definitions from an extensive description. In 19 out of 60 articles, we observed explicitly stated definitions (e.g. in a textual paragraph). However, only ten articles presented unique descriptions. The other nine definitions were already proposed in earlier work. Given the limited set of definitions, we manually retrieved the used field names, the objectives and approaches of the discipline (Table III). Important elements are marked: the name is highlighted in bold, the objectives are underlined and the approach is in italic.

Table III shows that we detected two names: "Sustainable" BPM and "Green" BPM. Concerning the objectives, we found authors proposing Elkington's (1997) sustainability dimensions, general environmental concerns or rather specific goals (e.g. a reduction of carbon emissions). Finally, we identified four categories by which the discipline intends to

Article	Definition
Ahmed and Sundaram (2012, p. 611)	"**Sustainable BPM** is an *approach for managing businesses* that draws on an integrated and balanced performance of the business's economic, environmental and social aspects, referred to as sustainability dimensions or the Triple Bottom Lines (TBL) of business management"
Ghose *et al.* (2009, p. 103)	"**Green BPM** describes a novel class of technologies that *leverage and extend existing BPM technology* to enable process design, execution and monitoring in a manner informed by the carbon footprint of process designs and instances"
Kuppusamy and Gharleghi (2015, p. 260)	"**Green BPM** entails *managing a manufacturing corporation's supply chain* by conforming to green standards and practices. This also involves management of the corporation's upstream supply chain because managing internal green processes can become effective if external parties' practices are also green"
Lübbecke *et al.* (2016b, p. 1049)	"**Green BPM** aims at the *design and optimization of IT-related processes* with regard to ecological objectives such as the resource consumption of business processes"
Nowak, Leymann and Schumm (2011, p. 570)	"**Green BPM** is not an entirely new way in optimizing organisations' business processes. In fact, *existing BPM methodologies and techniques are leveraged, extended, or refined* in order to support the new requirements emerging from environmental concerns"
Nowak, Leymann, Schumm and Wetzstein (2011, p. 2)	"While conventional BPM focuses on the *optimization of cost, quality, time, and flexibility of business processes*, **Green BPM** additionally considers the environmental perspective and the trade-off between them, before, during, or after process execution"
Opitz *et al.* (2014b, p. 3812)	"From an IS researcher's perspective, **Green BPM** is the sum of all *IS-supported management activities* that help to monitor and reduce the environmental impact of business processes in their *design, improvement, implementation or operation* stages, as well as lead to cultural change within the process life cycle"
Rozman *et al.* (2015, p. 249)	"**Sustainable BPM** means that we take a process-oriented approach to an organisation's primary way of management and we *continuously re-fine, measure, optimize and reengineer existing processes* or introduce new ones in our organisations, which cover all the sustainability dimensions (economic, social, environment)"
Seidel *et al.* (2012, p. 5)	"**Green BPM** concerns the *understanding, documenting, modelling, analysing, simulating, executing, and continuously changing of business process* with dedicated consideration paid to the environmental consequences of these business processes"
Seidel *et al.* (2011, p. 3)	"**Green BPM** can be regarded as an *intersection of both BPM and Green IS*. Only through process change, and the application of process-centred techniques, the transformative power of IS can be fully leveraged in order to create environmentally sustainable organisations and, in turn, an environmentally sustainable society"

Table III.
Overview of explicitly stated definitions and their important word groups for text analysis

reach its objectives. These categories are related to a comprehensive BPM approach or to the underlying traditions. The approaches are: quality control, business management, IS or an extension of existing BPM techniques. The classification is presented in Table IV, which also includes aggregated numbers of explicitly and implicitly stated definitions for all 60 articles.

4.2 "Green" BPM vs "Sustainable" BPM

Two explicit definitions used the term "Sustainable" BPM (Ahmed and Sundaram, 2012; Rozman *et al.*, 2015). They referred to the three sustainability dimensions (Elkington, 1997) as the discipline's objectives. In total, 17 articles used this term. However, three of them actually discussed environmental objectives (Curry and Donnellan, 2012; Gallotta *et al.*, 2016, 2017) so the term "Green" BPM was more appropriate here. Moreover, four other articles acknowledge Green BPM, next to sustainable BPM (Betz, 2014; Gallotta *et al.*, 2017; Schoormann *et al.*, 2017; Stolze *et al.*, 2012). This means that 10 out of 60 articles propose sustainable BPM in line with Elkington's (1997) TBL. The other 50 articles acknowledge Green BPM as associated with environmental considerations. For the remainder of this study, we do not exclude the articles on sustainable BPM as they are encompassing Green BPM.

4.3 Green BPM vs underlying BPM traditions

Two explicit definitions interpreted Green or sustainable BPM as a business management approach. Ahmed and Sundaram (2012) discussed "an approach for managing business" while Kuppusamy and Gharleghi (2015) examined "supply chain management." Three definitions mentioned an inevitable role for IS in Green BPM (Lübbecke *et al.*, 2016b; Opitz *et al.*, 2014b; Seidel *et al.*, 2011). Five explicit definitions described Green BPM as an extension of BPM methods and techniques.

The three major process traditions underlying BPM (Harmon, 2015) are important. For instance, two articles strongly rely on the quality control tradition by proposing a capability maturity model for corporate sustainability (Cleven *et al.*, 2012) and ICT sustainability (Curry and Donnellan, 2012). The same holds for the business management tradition: Zeise *et al.* (2012) presented performance measurement systems for sustainable companies. Other articles discussed sustainable business transformation (Ahmed and Sundaram, 2012), supply chains (Kuppusamy and Gharleghi, 2015) or project management (Sánchez, 2015; Silvius, 2012). With regard to the IS tradition, the score only reflects the inevitable role for IS claims (Lübbecke *et al.*, 2016b; Opitz *et al.*, 2014b; Seidel *et al.*, 2011). The vast majority of Green BPM literature in our sample adopted IT (e.g. Ardagna *et al.*, 2008; Balachandran, 2011; Cappiello *et al.*, 2013; Curry and Donnellan, 2012; Skarlat *et al.*, 2015; Thies *et al.*, 2012). However, this was always to support process-oriented techniques.

With 50 out of 60 articles, we found more evidence of Green BPM as an interdisciplinary approach. This is explicitly stated by some authors. For instance, Ardagna *et al.* (2008) aimed at the development of green business processes "based on expertise from web service technologies, data deduplication, optimization, performance evaluation and model identification" (p. 183). Dao *et al.*, (2011) developed a sustainability framework "illustrating the integration of human, supply chain, and IT resources to develop sustainability capabilities" (p. 63). According to von Rosing *et al.* (2015), sustainable processes can be achieved "by challenging the following areas: process design and operations, the link to strategy, and flows, roles involved, relevant rules, and compliance aspects as well as process automation, measurements, and reporting" (p. 493). These descriptions clearly combine the process traditions.

Other authors started from a comprehensive BPM framework reflecting aspects from the three traditions. In the study of Nowak, Leymann and Schumm, 2011, a holistic Green BPM approach is presented. First, a conventional BPL relying on the quality control and IS tradition

Table IV.
Overview text analysis of explicit definitions and aggregated numbers for explicit and implicit definitions

	Discipline name			Approach				Objectives	
	Sustainable BPM	Green BPM	Quality control	Business management	Information systems	Business process management	Sustainability concerns	General environmental concerns	Specific environmental concerns
Explicit definitions (n = 10)									
Ahmed and Sundaram (2012)	1			1			1		
Ghose *et al.* (2009)		1				1			1
Kuppusamy and Gharleghi (2015)		1		1				1	
Lübbecke *et al.* (2016b)		1			1			1	
Nowak, Leymann and Schumm (2011)		1				1		1	
Nowak, Leymann, Schumm and Wetzstein (2011)		1				1		1	
Opitz *et al.* (2014b)		1			1			1	
Rozman *et al.* (2015)	1						1		
Seidel *et al.* (2012)		1				1		1	
Seidel *et al.* (2011)		1			1			1	
Total	2	8	0	2	3	5	2	7	1
Explicit and implicit definitions (n = 60)									
Total	17	43	2	5	3	50	14	25	21

is introduced. Second, the value chain of Porter, a concept from the business management tradition, was used to identify Green BPM business requirements. Similarly, in the study of Opitz *et al.* (2014a), various capabilities were discussed that organisations should have in order to actually take advantage of Green BPM. Their "Green BPM readiness" capabilities are: "attitude", "strategy", "governance", "modelling", "optimizing" and "monitoring." Again, these six capability areas rely on a combination of the three traditions.

4.4 Green BPM vs conventional BPM

The analysis also showed that Green BPM addresses topics which are not addressed by conventional BPM. Concerning the objectives of Green BPM, one explicit definition (Ghose *et al.*, 2009) was rather specific (i.e. reduction of carbon footprint). The seven other explicit definitions had more general objectives (i.e. reducing the environmental harmful effects of business processes). In sum, 25 articles stated general environmental objectives while 21 articles were more specific (e.g. reduction of carbon emissions, Ahlers *et al.*, 2016; Ghose *et al.*, 2009; Hoesch-Klohe and Ghose, 2010a, b; Hoesch-Klohe *et al.*, 2010; Recker *et al.*, 2010, 2012; Wesumperuma *et al.*, 2011; Zeise *et al.*, 2012, or energy consumption, Balachandran, 2011; Betz, 2014; Cappiello *et al.*, 2013; Gallotta *et al.*, 2017; Jakobi *et al.*, 2016; Lübbecke *et al.*, 2015, 2016b; Nowak *et al.*, 2010, 2013; Reiter *et al.*, 2014; Skarlat *et al.*, 2015; Watson *et al.*, 2012). These results are not contradictory but can be interpreted as a higher or lower level of specialisation. These objectives are opposed to BPM's conventional dimensions of cost, quality, time and flexibility (Reijers and Liman Mansar, 2005). The question could also be raised if Green BPM methods and techniques differ from conventional ones (see Section 6, *RQ3*).

5. Results for *RQ2*

For analysing the ways of dissemination and the researchers involved, Figure 2 starts with an overview of the types of scholarly dissemination.

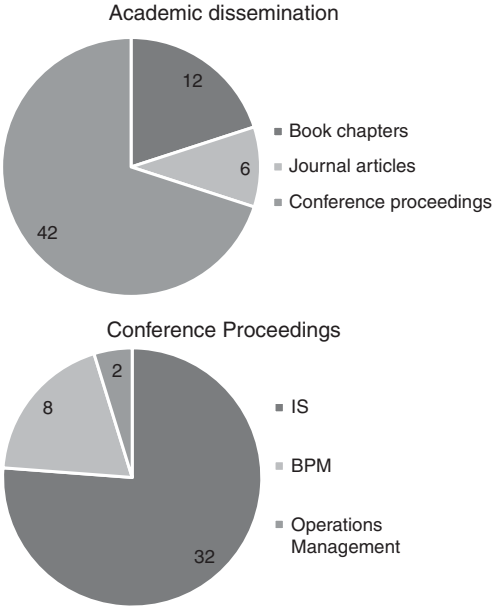


Figure 2.
Overview types of scholarly dissemination

In total, 12 contributions were issued as a book chapter. Nine of them were published in a book on Green BPM by vom Brocke *et al.* (2012). Although this book has 13 chapters, we only considered nine as a direct Green BPM contribution. Four chapters rather seemed to have a main focus on Green IS without discussing process-centred techniques and were thus excluded. Journal publications were limited and four out of six contributions concerned IS journals (Ahmed and Sundaram, 2012; Dao *et al.*, 2011; Ghose *et al.*, 2009; Lan, 2011). Finally, 42 out of 60 articles were conference proceedings. The International Conference on BPM is leading with eight papers (Couckuyt *et al.*, 2018; Larsch *et al.*, 2016; Lübbecke *et al.*, 2016a, 2018; Magdaleno *et al.*, 2016; Mancebo *et al.*, 2017; Recker *et al.*, 2010; Skarlat *et al.*, 2015). Two papers were presented on conferences in the field of operations management (Gallotta *et al.*, 2016, 2017) and 32 out of 42 papers were part of IS-related conferences.

We based the assessment of geographical origins on the institutional affiliation of the first author to examine how strong the topic of environmental sustainability in BPM is driven from specific countries. Table V shows the countries and number of publications.

The data showed that research groups in Germany and Australia are leading Green BPM research, with, respectively, 25 and 10 publications so far. Liechtenstein is following with three articles. However, it should be noted that the research group at the University of Liechtenstein (Seidel and vom Brocke) and the research group at the Queensland University of Technology, Australia (Recker) have co-edited the book on Green BPM (vom Brocke *et al.*, 2012). In general, with 41 out of 60 articles, European research groups are leading Green BPM research.

6. Results for *RQ3*

6.1 The classification framework

The classification framework presented in Section 2.3 has two purposes. First, it evaluates the scope of Green BPM. Second, it allows a comparison between Green BPM and conventional BPM methods and techniques. The sample was analysed to identify BPM-related capability areas and mapped on three possible categories: BPL, BPM and BPO. Since several articles could be mapped more appropriately, the scheme was extended with three additional categories, i.e. "practical", "focus" and "review." Our final classification framework is presented in Figure 3.

Two articles were classified as "practical" outside the capabilities categories because they investigated Green BPM in organisations. It concerns Levina (2015) with a content analysis of 78 case studies and Loepp and Betz (2015) which investigated the current state of Green BPM in German companies with an online survey. We also identified eight "review" articles:

- Schoormann *et al.* (2017) made an interesting contribution to Green BPM modelling and is discussed in the BPL category (Section 6.2).
- Four other articles presented a literature review (Gohar and Indulska, 2015; Maciel, 2017; Opitz *et al.*, 2014b; Stolze *et al.*, 2012). As they consider a comprehensive Green BPM approach, the six capability areas were discussed.

Table V. Overview countries and number of publications

Argentina	1	China	1	Malaysia	1	Sri Lanka	1
Australia	10	Germany	25	New Zealand	1	Switzerland	2
Austria	1	Ireland	1	Norway	1	The Netherlands	1
Belgium	2	Italy	2	Slovenia	1	UK	2
Brazil	1	Liechtenstein	3	Spain	1	USA	2

- Finally, three other review articles discussed the field of research as such. More specifically, two launched a call for action to immerse deeper into the role of business processes for environmentally sustainable organisations (Couckuyt, 2018; Seidel *et al.*, 2011). Another article concerns an introduction chapter for a Green BPM book to position the domain (Seidel *et al.*, 2012). As these contributions are introductory, they are classified outside the capabilities categories.

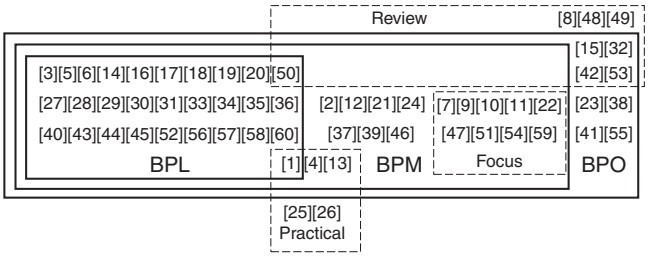
The third additional category of "focus" bundles articles concentrating on a particular management concept. These are discussed in the BPM category (Section 6.3).

6.2 Business process lifecycle

Figure 3 shows that 29 out of 60 articles were mapped on the BPL category. These articles focussed solely on the modelling, deployment and optimisation of environmentally sustainable business processes. Each paper discussed elements of all three capability areas. However, some articles had a main focus or interesting contribution on a particular capability area. Therefore, the results are discussed from this perspective. Table VI gives an overview of the covered topics.

Concerning the articles which explicitly focussed on "process modelling", we identified three approaches. Most authors extended existing modelling frameworks by adding emissions (e.g. Ghose *et al.*, 2009; Hoesch-Klohe and Ghose, 2010a, b; Recker *et al.*, 2010, 2012; Wesumperuma *et al.*, 2013) or energy (e.g. Ardagna *et al.*, 2008; Reiter *et al.*, 2014; Watson *et al.*, 2012) accumulation annotations across process designs. With these new elements (e.g. graphics, icons, indicators), the relationship was modelled between resources and activities to inform the business process with its emission or energy impact. Other articles reused and adapted existing BPM modelling notations from BPMN, UML or EPC to represent environmental aspects in business process modelling (Ahlers *et al.*, 2016; Gräuler and Teuteberg, 2013; Hoesch-Klohe *et al.*, 2010; Houy *et al.*, 2012; Lübbecke *et al.*, 2015). These two approaches were confirmed by Magdaleno *et al.* (2016), and are illustrated in Figure 4. Finally, a third approach relies on adding patterns to apply existing knowledge for enhancing process models. Ecological business process patterns are then presented to examine environmental impact (Lübbecke *et al.*, 2016a, b, 2018; Nowak and Leymann, 2013). The three approaches are confirmed by Schoormann *et al.* (2017), which provides a review of Green BPM modelling.

Three other papers do not discuss a detailed modelling approach as such. Betz (2014) presented a more conceptual approach to support sustainability-aware BPM using XML-Nets. In the study of Lübbecke *et al.* (2018), a set of guidelines for ecology-aware process design was proposed. We believe these principles can be applied to the three approaches identified above. Finally, Opitz *et al.* (2012) used a literature analysis and three case studies to derive suitable languages and software.



Note: $n = 60$

Figure 3.
Overview classification of articles

Capability area	Topics covered
Modelling	Three main modelling approaches Extending notations (Ardagna *et al.*, 2008; Ghose *et al.*, 2009; Hoesch-Klohe and Ghose, 2010a, b; Recker *et al.*, 2010, 2012; Reiter *et al.*, 2014; Watson *et al.*, 2012; Wesumperuma *et al.*, 2013) Adding notations (Ahlers *et al.*, 2016; Gräuler and Teuteberg, 2013; Hoesch-Klohe *et al.*, 2010; Houy *et al.*, 2012; Lübbecke *et al.*, 2015) Adding patterns (Lübbecke *et al.*, 2018, 2016a, b; Nowak and Leymann, 2013) Conceptual modelling approach using XML-nets (Betz, 2014) Modelling guidelines (Lübbecke *et al.*, 2018) Suitable existing modelling languages and software (Opitz *et al.*, 2012) Review on modelling techniques (Schoormann *et al.*, 2017)
Deployment	Measuring and controlling emissions (Ahlers *et al.*, 2016; Ghose *et al.*, 2009; Wesumperuma *et al.*, 2011) or energy (Cappiello *et al.*, 2013; Nowak *et al.*, 2013; Skarlat *et al.*, 2015) Innovative implementation and enactment approaches (Mancebo *et al.*, 2017; Zhu *et al.*, 2015)
Optimisation	Benchmarking of alternative process designs (Cappiello *et al.*, 2013; Ghose *et al.*, 2009) Semi-automatic tools for process re-design (Gräuler and Teuteberg, 2013; Hoesch-Klohe and Ghose, 2010a, b; Hoesch-Klohe *et al.*, 2010; Lübbecke *et al.*, 2015) Optimisation of inter-operating processes (Cappiello *et al.*, 2013; Ghose *et al.*, 2009; Wesumperuma *et al.*, 2011) Environmental optimisation together with traditional dimensions (Wesumperuma *et al.*, 2011)

Table VI.
Topics covered for each capability area of the BPL category

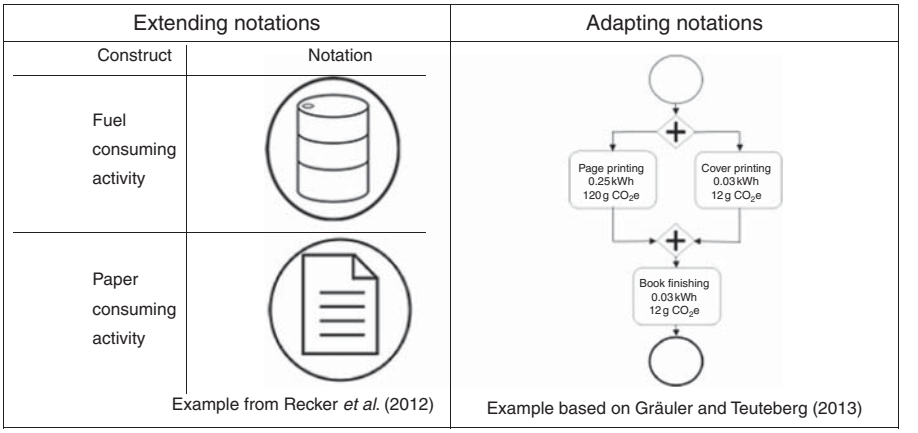


Figure 4.
Examples of extending and adapting modelling notations

Articles explicitly focussing on deployment used formulas and standards of environmental authorities to calculate emissions in business processes (Ahlers *et al.*, 2016; Ghose *et al.*, 2009; Wesumperuma *et al.*, 2011). Similarly, articles investigating energy consumption presented suitable metrics to monitor the energy efficiency of processes (Cappiello *et al.*, 2013; Nowak *et al.*, 2013; Skarlat *et al.*, 2015). For the implementation and enactment of ecological processes, two articles offer an innovative approach (Mancebo *et al.*, 2017; Zhu *et al.*, 2015). In the study of Mancebo *et al.* (2017), a BPMS-Game tool was presented which combines the concepts of gamification, sustainability and business processes to support games promoting sustainability in BPM. On the other hand, Zhu *et al.* (2015) provided an approach that allows executable process models to be integrated with Geographical IS. They illustrated feasibility by means of an exemplary process with ecological concerns.

Except for the two above-mentioned innovative approaches, the optimisation of business processes for environmental objectives seemed to rely on conventional BPM. Once process modelling and deployment is enriched with an environmental dimension as described above, optimisation is done by, for instance, benchmarking of alternative process designs that are extracted from continuous monitoring and data analysis (Cappiello *et al.*, 2013; Ghose *et al.*, 2009). Some authors offered semi-automatic tools for this process re-design (Gräuler and Teuteberg, 2013; Hoesch-Klohe and Ghose, 2010a, b; Hoesch-Klohe *et al.*, 2010; Lübbecke *et al.*, 2015). Finally, we found articles that did not merely focussed on the optimisation of single processes, but on inter-operating processes (Cappiello *et al.*, 2013; Ghose *et al.*, 2009; Wesumperuma *et al.*, 2011).

6.3 Business process management

As shown in Figure 3, 18 out of 60 articles were mapped on the BPM category. Within this category, nine articles extended the BPL with a management dimension to achieve (environmentally) sustainable business processes. For instance, Ahmed and Sundaram (2012) presented a sustainable business transformation cycle with five steps: "monitor and control", "discover and learn", "strategize", "design" and "transform." Some authors relied on existing lifecycles to achieve sustainable business processes. For instance, Larsch *et al.* (2016) used the work of Weske (2012) and Jakobi *et al.* (2016) adapted the lifecycle of Dumas *et al.* (2013). Finally, Rozman *et al.* (2015) relied on the BPM capability areas framework of de Bruin and Rosemann (2007) to integrate environmental sustainability topics. In the studies of Nowak *et al.* (2010), Nowak, Leymann, Schumm and Wetzstein (2011), Green Business Process Reengineering was described as an architecture and methodology consisting of four layers, i.e. "strategy", "sensing and monitoring", "analysis and management" and "adaptation." We also observed two more practical contributions (Balachandran, 2011; Gallotta *et al.*, 2017). Balachandran (2011) presented the transformation to a green telecommunications company consisting of four stages: "strategy", "design", "realisation" and "operational." Gallotta *et al.* (2017) described a study in a biomass power generation company using a BPM framework for sustainable business processes (Gallotta *et al.*, 2016).

Nine other articles in the BPM category solely focussed on a particular management concept without discussing capability areas of the BPL category. The below list gives a summary of interesting management concepts identified in the light of environmental objectives.

Identified management concepts for environmental objectives:

- key ecological indicators (KEIs) as an extension of key performance indicators (KPIs) linked to an environmental strategy (Couckuyt *et al.*, 2018; Nowak *et al.*, 2010; Nowak, Leymann, Schumm and Wetzstein, 2011; Thies *et al.*, 2012; Zeise *et al.*, 2012);
- maturity models to improve capabilities to meet sustainability objectives (Cleven *et al.*, 2012; Curry and Donnellan, 2012);
- sustainability frameworks for organisations or a single business process (Couckuyt *et al.*, 2018; Dao *et al.*, 2011);
- roles and responsibilities (Jakobi *et al.*, 2016; Nowak, Leymann, Schumm and Wetzstein, 2011);
- external relationships (Jakobi *et al.*, 2016; Kuppusamy and Gharleghi, 2015; Nowak, Leymann, Schumm and Wetzstein, 2011; Thies *et al.*, 2012); and
- sustainability in project management (Sánchez, 2015; Silvius, 2012).

We noticed the concept of KEIs to plan and define the environmental performance of organisations (Couckuyt *et al.*, 2018; Nowak *et al.*, 2010; Nowak, Leymann, Schumm and Wetzstein, 2011; Thies *et al.*, 2012; Zeise *et al.*, 2012). KEIs can be seen as a Green BPM extension of traditional KPIs. Environmental performance management in organisations

was also recognised in the study of Cleven *et al.* (2012) by presenting an environmental capability maturity model to determine the process performance. Similarly, Curry and Donnellan (2012) used a maturity model for sustainable ICT. We also found company-wide frameworks. For instance, Dao *et al.* (2011) used the resource-based view as theoretical foundation for a company's sustainability capabilities integrating human, supply chain and IT resources. Couckuyt *et al.* (2018) introduced a preliminary classification framework summarizing sustainability models and indicators, both for entire organisations or single business processes.

Roles and responsibilities also appeared to gain importance. According to Nowak, Leymann, Schumm and Wetzstein (2011), top management should be involved with strategy and define KEIs. The operational staff should be involved with sensing and monitoring, the business analyst with analysis and management and the business architect with adaptation. Moreover, external relationships were recognised to be important as the optimisation of energy consumption should go beyond the company. These internal roles and external relationships were further stressed by Jakobi *et al.* (2016). Successful Green BPM requires the participation of stakeholders in all process lifecycle phases. The influence of green supplier selection, green supplier monitoring and green supplier collaboration towards Green BPM was examined in the study of Kuppusamy and Gharleghi (2015). To enhance the exchange of sustainability indicators, Thies *et al.* (2012) presented a common platform were providers and consumers of environmental data can connect.

Finally, Sánchez (2015) and Silvius (2012) explored the application of sustainability to project management. Both works argued that companies integrate ideas of sustainability in their marketing, corporate communications, and in their annual reports. Many of these actions are organised in projects. Therefore, project management should address an environmental sustainability agenda.

6.4 Business process orientation

The BPO category contained four articles focussing on general environmental objectives and discussing all six capability areas. Subsequently, we elaborate on specific elements detected for the capability areas "culture" and "structure." Table VII gives a summary of the topics.

For the "culture" capability area, Nowak, Leymann and Schumm (2011) mentioned the attitudes and behaviours of employees as important. Internal guidelines advise employees in their daily resource usage and lead to a rethinking of established usage patterns. Lan (2011) proposed training programmes for pedagogical and professional development. By gaining essential skills and knowledge, participants will continue carrying out green business processes. Employees' behaviour was extended with a company's attitude by Opitz *et al.* (2014a) and von Rosing *et al.* (2015). In the study of Opitz *et al.* (2014a), it was stated that the attitude of a company and its employees towards ecological sustainability is a basic factor for implementing long-term Green BPM. von Rosing *et al.* (2015) paid considerable

Table VII.
Topics covered for the capability areas "culture" and "structure"

Capability area	Topics covered
Culture	Green behaviours of employees (Lan, 2011; Nowak, Leymann and Schumm, 2011; Opitz *et al.*, 2014a; von Rosing *et al.*, 2015)
	Training programmes for employees (Lan, 2011)
	Green attitudes of companies (Opitz *et al.*, 2014a; von Rosing *et al.*, 2015)
Structure	Environmental aware governance bodies (Nowak, Leymann and Schumm, 2011)
	New governance bodies or actors (Opitz *et al.*, 2014a; von Rosing *et al.*, 2015)

attention to company values. The first and second steps in their seven-step plan towards sustainability-oriented processes were dedicated to culture and values in particular.

Also, elements of the capability area "structure" were detected. In the study of Nowak, Leymann and Schumm (2011), the value chain of Porter was used to identify new business requirements relevant to Green BPM. The primary and support activities were all discussed for sustainability. It was stated that specific governance bodies responsible for these primary and support activities should reflect on and optimise processes for environmental objectives. von Rosing *et al.* (2015) established a sustainability board and defined sustainability owners to ensure sustainability governance. In the study of Opitz *et al.* (2014a), it was mentioned that a Chief Ecological Officer, responsible for the green strategy, should be implemented within the organisational structure.

7. Discussion

7.1 Discussion for RQ1

A vast majority of authors agree on the term "Green" BPM (instead of "Sustainable" BPM) by relying on other process change traditions in order to reduce the environmentally harmful effects of business processes. We distinguish Green BPM from conventional BPM in two manners. First, the environmental objectives are opposed to BPM's conventional dimensions of cost, quality, time and flexibility (Reijers and Liman Mansar, 2005). Second, as presented in Section 6 (*RQ3*), Green BPM provides methods and techniques different from the conventional ones. To offer a common understanding among participants, we now propose the following definition:

> Green BPM extends the optimisation of cost, quality, time, and flexibility of business processes with an environmental sustainability dimension. This means that Green BPM concerns the modelling, deployment, optimisation and management of business processes with dedicated consideration paid to their environmental consequences. In order to facilitate successful Green BPM, organisational capability areas (i.e. culture, structure) should also be considered as important.

Currently, Green BPM research mainly focusses on the capability areas for process "modelling", "deployment", "optimisation" and "management." Since we also found literature on the capability areas of "culture" and "structure", it is important to include them in a comprehensive definition. We noted diverse attitudes towards the Green BPM methods and techniques, which can be attributed to the underlying BPM traditions. Research participants from one tradition often ignore or depreciate other approaches. On the other hand, this diffusion serves as evidence for Green BPM as an interdisciplinary approach. We identified frameworks, concepts and techniques from different process change traditions, offering opportunities for further research. As Green IS researchers already had a significant influence, participants from the quality control and business management tradition can also have a more relevant contribution in the development of Green BPM (see *RQ3*).

7.2 Discussion for RQ2

Our sampled Green BPM articles were disseminated through scholarly conferences (42), journals (6) and book chapters (12). Noteworthy is the high number of conference proceedings and the low number of journal publications. This can be explained by shorter publication cycles for most conferences and the relatively recent uptake of Green BPM research. Alternatively, it might be an indication that Green BPM research remains a (side-) project of some researchers. Nonetheless, we evoke to concentrate on Green BPM as a discipline and to deliver high-quality journal publications. Moreover, we uncovered that only 8 out of 42 papers were presented on BPM-related conferences. Giving more attention

to Green BPM on BPM platforms where process-centred techniques are central will further enhance the development of the field.

In general, European research groups are leading Green BPM research. To further establish Green BPM worldwide, also non-European research groups are encouraged to participate more strongly. We specially reach out to research groups from North America because they already have a strong tradition in process change.

7.3 Discussion for RQ3

While evaluating the Green BPM literature against the critical capability areas of Van Looy *et al.* (2014) (Table II), we revealed that Green BPM follows a similar evolution as the BPM discipline. In early BPM research, the main focus was on the traditional BPL (de Bruin, 2007). Especially the "modelling" capability area is already well-documented. Three approaches (i.e. extending modelling notations, adapting modelling notations and adding patterns) have been extensively discussed. For the "deployment" capability area, the study uncovered some innovative implementation and enactment approaches (e.g. gamification, Mancebo *et al.*, 2017 and geographical IS, Zhu *et al.*, 2015). Much attention has been paid to frameworks, consisting of formulas and standards, to measure and control emissions or energy in business processes. The optimisation of business processes for environmental objectives still relies on conventional BPM methods and techniques. Consequently, process modelling and deployment has been enriched with an environmental dimension. Green process optimisation can be done, for instance, by benchmarking of alternative process designs.

As not all capability areas are properly covered, avenues exist for further research and in particular for the managerial, cultural and structural areas of Green BPM. For "management", aspects concerning strategy and KEIs, roles and external relationships have been discussed. However, a list of other management topics is missing, such as employee skills, training and change management. Concerning the "culture" capability area, ecological values and behaviours of employees are only briefly discussed. Also topics on appraisals and rewards, or top management commitment should be investigated in more detail from the perspective of Green BPM. This also holds for the capability area of "structure": we specifically call for future research on green governance bodies or actors. Finally, as we only found three practical contributions related to BPL (Ahlers *et al.*, 2016) or BPM (Balachandran, 2011; Gallotta *et al.*, 2017), we recommend research on concrete applications for all capability areas.

8. Conclusion

This study has presented a systematic literature review of the Green BPM field. We have offered a comprehensive definition for the discipline (*RQ1*), and a research agenda by focussing on the current state (*RQ2*) and the methods and techniques (*RQ3*).

The comprehensive definition for Green BPM (*RQ1*) facilitates a common understanding to let the Green BPM discipline further mature, given the international importance of a green economy and the interdisciplinary character of sustainable objectives.

Regarding the current state (*RQ2*), this work has provided evidence that Green BPM needs more attention on BPM communication channels to bridge the relevance gap with rigorous research. This work calls for more research on Green BPM, and especially from an international perspective. For instance, more non-European research groups should get involved.

Finally, *RQ3* completes the research agenda by differentiating highly covered Green BPM capability areas from emerging areas. Based on the identified gaps, possible research avenues have been presented.

In sum, despite some typical SLR research limitations (e.g. sampling strategy), the research questions have generated a comprehensive overview about Green BPM application domains and research topics.

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Table AI.

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