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Review

Green BPM as a Business-Oriented Discipline: A Systematic Mapping Study and Research Agenda

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Abstract: Green Business Process Management (BPM) focuses on the ecological impact of business processes. This article provides a systematic mapping study of Green BPM literature to evaluate five attributes of the Green BPM research area: (1) scope, (2) disciplines, (3) accountability, (4) researchers and (5) quality control. The results allow developing a research agenda to enhance Green BPM as an approach for environmentally sustainable organizations. We rely on a dichotomy of knowledge production to present research directives relevant for both academics and practitioners in order to help close a rigor-relevance gap. The involvement of both communities is crucial for Green BPM to advance as an applied, business-oriented discipline.

Keywords: Green BPM; systematic mapping study; environmental sustainability

1. Introduction

Organizations are becoming more environmentally-aware [1]. As part of an environmental business strategy, an optimization of operations in the light of ecological objectives has gained importance [2]. Business Process Management (BPM), which refers to "*the art and science of overseeing how work is performed in an organization to ensure consistent outcomes and to take advantage of improvement opportunities*" [3] (p. 1), is a key starting point. Recently, researchers increasingly advocate to extend the scope of BPM's conventional dimensions [4] with an environmental sustainability dimension [5]. This new approach is called Green BPM [6–9]. As stated by Nowak et al. [10], "*while conventional BPM is focused on the optimization of costs, quality, time and the flexibility of the business processes, Green BPM additionally considers the environment and the balance among all of the perspectives*" (p. 169).

Depending on the type of business process considered, environmental sustainability can take different forms in Green BPM. For instance, the reduction of electricity consumption [11] or carbon emissions [12] can be considered as ecological optimization objectives for business processes. Both conventional and environmentally sustainable process-related objectives can be addressed by so-called process-centered techniques which support the design, configuration, enactment, evaluation and administration of business processes [13]. Therefore, authors introduce environmental certification in the process design [2], present Key Ecological Indicators (KEIs) to evaluate the environmental performance of organizations [14], or introduce Green BPM specific roles and responsibilities such as an Ecological Officer [2,15,16]. More formally stated, "*Green BPM concerns the understanding, documenting, modelling, analyzing, simulating, executing, and continuously changing of business process with dedicated consideration paid to the environmental consequences of these business processes*" [17] (p. 5).

BPM originates from three process change traditions: (1) the Quality Control tradition with a main focus on the production of products, (2) the Business Management tradition considering a firm's overall performance, and (3) the Information Systems (IS) tradition with IT as the major force driving business changes [18]. The process-centered techniques in BPM typically rely on these traditions.

For instance, in the context of Green BPM, Cleven et al. [19] presented a capability maturity model for corporate sustainability (i.e., Quality Control), Zeise et al. [20] discussed a performance measurement system for sustainable companies (i.e., Business Management tradition), and Opitz et al. [8] claimed a central role for IT (i.e., IS tradition).

There is a general belief in the field of BPM that these process change traditions are merging into a more comprehensive approach [2,15,18]. Nonetheless, some potential still exists for a further integration of these process change traditions in the field of Green BPM. By relying on these but also other relevant disciplines, Green BPM can enlarge its set of process-centered techniques as demanded by both academics and practitioners [5,21–24].

As a response, the goal of this study is to propose a research agenda relevant for both academics and practitioners. We aim towards ecological business processes by incorporating still under-investigated topics. Moreover, we intend to bridge a rigor-relevance gap by relying on a dichotomy of research modes [25,26]. According to Gibbons et al. [25], a new approach (i.e., Mode 2, practical relevance) is evolving out of, and coexisting with, the traditional protocols (i.e., Mode 1, scientific relevance). These two modes differ among five important attributes, namely (1) scope, (2) disciplines, (3) accountability, (4) researchers and (5) quality control. For an applied and business-oriented discipline as Green BPM, a balance between the two modes is vital. By relying on this dichotomy of research modes [25,26], the research agenda for further Green BPM development ensures both academic and practical relevance.

The research agenda is constructed by conducting a systematic mapping study, which is designed to give an overview of a specific research area through classification and counting contributions in relation to the categories of that classification [27,28]. With regard to this classification, Petersen et al. [28] have made a distinction between fixed classification schemes (i.e., that are not highly dependent on the specific topic investigated) and topic-specific classification schemes. The dichotomy of research modes [25,26] serves as a fixed classification scheme and constitutes the basis of the research agenda. Subsequently, for each of the five attributes, we add Green BPM-specific classification schemes. These classification schemes rely on well-accepted sustainability concepts, BPM frameworks and bibliometric analysis techniques.

By following a systematic mapping protocol, we collect a sample of Green BPM literature which is evaluated for each Mode 1 attribute. Five research questions in line with the five attributes will facilitate the topic-specific classification. These results provide us with research directives for Mode 1 and simultaneously enable us to make research suggestions for Mode 2 applications. In sum, we present a research agenda to advance in Green BPM as an applied and business-oriented discipline.

This study has social, business and academic purposes. As the effects of environmental degradation concerns the entire society, industries should urgently take responsibility. Green BPM research helps businesses make environmental considerations since Green BPM techniques can be used by practitioners to environmentally optimize their processes. From an academic point of view, the research agenda provides gaps in the field and recommendations for further research. Simultaneously, practitioners can check if current theory and knowledge is relevant to them in order to deliver practically useful results and they can also contribute to Green BPM developments.

The remainder of this article continues with related work in Section 2. Next, the methodology is detailed in Section 3, and results are presented in Section 4. Finally, the research agenda is provided and discussed in Section 5, followed by concluding comments (Section 6).

2. Theoretical Background

The following sections present related work to understand the classifications in this mapping study. More concretely, we present theoretical foundations for the classification frameworks adopted for the attributes of (1) scope (Section 2.3), (2) disciplines (Section 2.2), and (3) accountability (Section 2.1). For these classification schemes, we rely on well-accepted sustainability concepts and BPM frameworks. Classification frameworks for the attributes of (4) researchers and (5) quality control are not discussed in this section as these evaluations are based on a bibliometric analysis.

2.1. Environmental Sustainability in Green BPM

Sustainable development is defined as "*the development that meets the needs of the present world, without compromising the ability of future generations to meet their own needs*" [29] (p. 37). The Triple Bottom Line (TBL) of Elkington [30] distinguished three dimensions of sustainability, namely economic, social and environmental. Organizations should focus on all three interdependent dimensions to succeed in the long run [30]. Therefore, it is also fundamental to include sustainability in BPM. These sustainable BPM techniques have been denominated as Green BPM [5,7–9]. The goal of Green BPM is to reduce the environmental impact of business processes [5,7–9]. Green BPM differs from conventional BPM in the objectives and approaches to realize its goals.

First, with regard to the approaches, the distinct goal implies that existing BPM techniques are leveraged, extended, or refined in order to support the new requirements emerging from environmental concerns [10]. For instance, the design of a business process will differ if environmental certification is intended. Alternative raw materials or different resource usage may influence the production process [2]. The environmental objective also involves different measures to evaluate the performance of business processes. BPM's traditional Key Performance Indicators (KPIs) exhibit shortcomings and therefore Green BPM scholars present Key Ecological Indicators (KEIs) to evaluate the environmental performance [14]. Moreover, the environmental objective can also require the introduction of Green BPM actors. Alternative modelling frameworks, business processes, and performance indicators necessitate an extensive administration and management. Therefore, different authors propose an Ecological Officer as a cross-discipline position that closely collaborates with other stakeholders [2,15,16].

Secondly, with regard to the more concrete objectives, environmental sustainability at the individual company level can take different forms. For instance, from a business model perspective, Bocken et al. [31] distinguished different sustainable archetypes such as: "maximize material and energy efficiency", "create value from waste" and "substitute with renewables and natural processes". Similarly, from a business process perspective, environmental sustainability can take different forms in Green BPM. For instance, the reduction of electricity consumption [11] or carbon emissions [12] can be considered as possible environmental sustainable practices.

In this study, we address the attribute of (3) accountability, i.e., the more concrete environmental objective, by starting from Elkington's TBL [30] as a classification scheme. This classification is then narrowed based on Green BPM objectives identified in the literature.

2.2. Foundations of Green BPM

To evaluate the attribute of (2) disciplines, we looked at the foundations of BPM that are preceding Green BPM to identify an appropriate classification scheme. Several authors have discussed the conceptual roots, evolution and development of the BPM field [18,32–35]. In this study, we rely on a broad survey within the business process movement presented by Harmon [18]. Harmon's framework [18] consolidates several contributions of the BPM foundations [32–35] in three underlying process change traditions: (1) the Quality Control tradition, (2) the Business Management tradition, and (3) the Information Systems (IS) tradition. These three traditions propose different approaches to business process change and each emphasizes some practices over others. Currently, there is a tendency of combining the various traditions in a comprehensive BPM approach [18,32–35]. Therefore, in Table 1, BPM is presented as a process change approach on top of the three underlying process change traditions. Some illustrative examples are also included.

First, the Quality Control tradition is a continuation of Taylor's Work Simplification [36], and its systematic experimentation to identify the best way of performing tasks. Later on, Total Quality Management (TQM), Six Sigma and Lean followed. These approaches implement an organizational transformation that embraces processes throughout the organization. Subsequently, Capability Maturity Models (CMM) were developed, which originally focused on software applications, but are now generalized to entire companies. While the Quality Control tradition focuses on the quality and the production of products, the Business Management tradition considers a firm's overall performance.

The second tradition's emphasis is on strategic alignment and on managing employees to achieve corporate goals. Important frameworks within this tradition are Porter's Value Chains [37] and the Balanced Scorecard [38]. Thirdly, the IS tradition started with a main focus on software automation. Process work was introduced by the Business Process Reengineering approach [39,40]. Such authors considered comprehensive processes, similar to Porter's Value Chains, but they simultaneously argued that the major force driving business changes was IT. Later on, application-based process redesign approaches followed, such as Process Modelling Tools [41], Enterprise Resource Planning Applications [42], and Business Rules [43]. As these process traditions underlie BPM, in this work, we verify the extent to which those traditions have been applied to Green BPM.

Table 1. Overview of approaches to business process change, including illustrative examples.

Business Process Management		
Quality Control	**Business Management**	**Information Systems**
Taylor's Work Simplification	Porter's Value Chain	Business Process Reengineering
Quality movement (TQM, Six Sigma, Lean)	Balanced Scorecard	Process Modelling Tools
Capability Maturity Models		Enterprise Resource Planning Applications
		Business Rules

2.3. Technical and Managerial Capabilities of Green BPM

Intuitively, a well-accepted classification framework in the field of BPM could serve as a starting point to evaluate the scope of Green BPM techniques. Business process maturity models (BPMMs) seem to be appropriate candidates because they help organizations in developing BPM strategies and roadmaps to guide their ongoing process efforts [44]. Therefore, as companies have a wide variety of activities, a BPMM should cover all capabilities in BPM. In the last decade, BPM researchers and practitioners have developed a long list of BPMMs with varied focus and depth [44–48]. As only a limited set of BPMMs has been verified by sufficient empirical research [49], we opt for a classification scheme that distinguishes between technical and managerial capabilities. These two categories encompass the more detailed but also varied capabilities offered by several BPMMs [44–48] and can easily be aligned with the process change traditions described in Section 2.2.

Process improvements involve consecutive and iterative phases, which are often represented by a business process lifecycle. The traditional business process lifecycle relied on the established Plan-Do-Check-Act cycle [50]. BPM initially focused on technical capabilities such as process modelling, deployment and optimization [3], which are mainly extracted from the Quality Control and IS traditions. Afterwards, management capabilities originating from the Business Management tradition gained importance [13], including organizational capabilities such as culture and structure to better support process improvements [51]. This more holistic BPM approach is called business process orientation (BPO) [46].

In general, technical capabilities comprise methods and IT for the modelling, deployment and optimization of business processes while managerial capabilities consider the daily management, including the required roles and responsibilities with corresponding skills and training. They also involve linking process goals to the organizational strategy and the relationships with customers, suppliers and other stakeholders. Finally, managerial capabilities include organizational values and their translation into attitudes and behavior, appraisals and rewards, top management commitment, and specific organizational bodies [44].

In the remainder, we verify the degree to which those BPM capabilities have been covered in Green BPM. Both technical and managerial capabilities are essential in a holistic Green BPM approach.

As indicated by vom Brocke et al. [52] "*BPM should not be solely conceived as a modeling exercise only but as a holistic approach that comprises, for example, strategic, methodological, technical and social aspects*" (p. 535).

3. Research Method

Systematic mapping studies are designed to provide an overview of a particular research area, such as Green BPM, by means of a classification and by counting contributions per category of that classification [27,28]. Although a systematic mapping study and a systematic literature review both follow a search protocol, they are different in terms of research questions, the selection and quality criteria, and results [53]. First, according to Kitchenham et al. [53], mapping studies start from general research questions as they aim to discover research trends while systematic reviews formulate very specific research questions as they focus on aggregating evidence. Secondly, the selection and quality criteria can be less stringent for mapping studies as they aim at research trends. For systematic reviews, these criteria are more essential as all studies must be found and the quality of the primary studies should be guaranteed to strengthen the aggregated evidence. Finally, the result of a systematic review typically consists of synthesized evidence as an answer to a specific research question whereas the outcome of a mapping study is an inventory of papers on the topic area. Hence, a mapping study typically provides an overview of the scope of the area and allows the discovery of research gaps and trends [27,28,54]. As Green BPM is a still-emerging discipline, we aim to present these research gaps and trends. Therefore, the classification frameworks for the attributes of (1) scope, (2) disciplines and (3) accountability (presented in Section 2) are clearly topic-driven and are the main focus of this study. The bibliometric analysis for the attribute of (4) researchers and (5) quality control, provides some additional information. Figure 1 shows the protocol of the present study, based on several systematic mapping contributions [27,28,55–57].

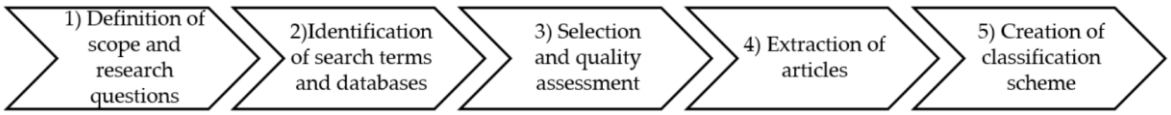


Figure 1. The systematic mapping protocol (designed by authors).

3.1. Definition of Scope and Research Questions

The goal of this mapping study is to provide a Green BPM research agenda. To ensure relevance for both academics and practitioners, we relied on a dichotomy of research modes as initially presented by Gibbons et al. [25]. The traditional research mode (i.e., Mode 1, ensuring scientific relevance) is supplemented with a new approach for research production (i.e., Mode 2, ensuring practical relevance). Mode 1 and Mode 2 differ among five important attributes, namely (1) scope, (2) disciplines, (3) accountability, (4) researchers and (5) quality control.

Firstly, Mode 2 knowledge occurs in a context of applications in which practitioners solve real-world problems through collaboration and communication. On the other hand, Mode 1 research emphasizes the creation of theory and knowledge within academia. Although Mode 1 can also result in practical applications, it requires a knowledge transfer which does not exist in Mode 2. As Mode 1 and Mode 2 occur in different contexts, the scope of knowledge can vary. Secondly, with regard to the disciplines involved, Mode 2 represents transdisciplinarity. This goes beyond interdisciplinarity (i.e., Mode 1) in the sense that once theoretical consensus is attained, it cannot easily be reduced to disciplinary parts. Mode 2 research is more likely to involve transdisciplinarity because of collaborations between academia, industry and society partners. Thirdly, compared to Mode 1, Mode 2 knowledge is rather based on a dialogue and has the capacity to incorporate multiple views, resulting in greater levels of social accountability. Fourthly, heterogeneous organizations conduct Mode 2 research. This means that, beyond traditional universities (i.e., Mode 1), also non-academic research centers, government agencies and consultancies are typically involved. Finally, Mode 2 research assesses quality by additional principles, e.g., economic, political, social and cultural criteria.

Its primary target for dissemination of research results is a practitioner audience, which contrasts to the scholarly platforms used in Mode 1.

In order to avoid a dichotomy trap in which one mode is represented as better than the other, we followed Etzkowitz and Leydesdorff [26] who see scientific disciplines as dynamic knowledge systems. Mode 1 research can be embedded in Mode 2 work, and vice versa. For an applied discipline such as Green BPM, maintaining a balance between the two modes is vital. Too much emphasis on Mode 1 results in stagnation and a lack of relevance. On the other hand, too much attention to Mode 2 leads to a lack of rigor. In sum, addressing the Green BPM research agenda as a dynamic Mode 1 and Mode 2 knowledge interaction ensures both scientific and practical relevance.

To facilitate the construction of such a Green BPM research agenda, we developed five research questions in line with the five attributes of Mode 1 and Mode 2 knowledge production (i.e., RQ1 relates to attribute (1), . . . , whereas RQ5 relates to attribute (5) respectively). The research questions are as follows:

- RQ1. Which capabilities are covered in Green BPM?
- RQ2. Which disciplines are involved in Green BPM?
- RQ3. Which environmental problems are addressed by Green BPM?
- RQ4. Which researchers are involved in Green BPM?
- RQ5. Which ways of dissemination are used in Green BPM?

Each research question evaluates our sample of Green BPM literature for one Mode 1 attribute. For this evaluation, we relied on the classification frameworks presented in Section 2 (RQ1, RQ2 and RQ3) or an a bibliometric analysis (RQ4 and RQ5). These results provided us with research directives for Mode 1 and simultaneously enabled us to make research suggestions for Mode 2 applications. More details on the contribution of the research questions are given in Section 3.5 in which the integrated classification framework is presented.

3.2. Identification of Search Terms and Databases

From four literature reviews on Green BPM [6–9], we learned that Green BPM is an emerging field of research for which a profound research agenda is missing. We also observed different terms related to the field of Green BPM. We thus selected a search string that combined four key terms ("Green Business Process Management", "Green BPM", "Sustainable Business Process Management", "Sustainable BPM") with an OR-operator, as a starting point for our study. In January 2019, the automated search was conducted in seven academic databases (i.e., Web of Science, Scopus, Emerald Insight, EBSCOhost Research Databases, IEEE Xplore Digital Library, Springer an AISeL). Table 2 presents the databases, search strings and results. As the identification of all potential research gaps and trends is key to systematic mappings, we opted for a search in multiple databases that contain only peer-reviewed articles. We further endeavored the objective to capture all research gaps and trends by investigating the citations in these primary studies (i.e., backward snowballing).

Table 2. Overview of databases, search strings and number of search results.

Database	Search String	Results
Web of Science	TOPIC: ("Green Business Process Management" OR "Green BPM" OR "Sustainable Business Process Management" OR "Sustainable BPM") Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI.	17
Scopus	TITLE-ABS-KEY (("Green Business Process Management" OR "Green BPM" OR "Sustainable Business Process Management" OR "Sustainable BPM"))	39

Table 2. *Cont.*

Database	Search String	Results
Emerald Insight	("Green Business Process Management" OR "Green BPM" OR "Sustainable Business Process Management" OR "Sustainable BPM")	19
EBSCOhost Research Databases		3
IEEE Xplore Digital Library		11
Springer		58
AISeL		45

3.3. Selection and Quality Assessment

Table 3 presents the inclusion, exclusion and quality criteria to select literature relevant for answering the research questions [28]. We included articles found by the search strategy described in Section 3.2. The upper time boundary was set by the moment of executing our automated search, namely January 2019. Finally, the articles had to be written in English. We excluded duplicated articles and unrelated papers, i.e., if they did not have a direct link with Green BPM or a Green BPM capability. While the automated search resulted in explicit Green BPM articles because of the search terms, this exclusion criteria was more relevant for papers retrieved by citations. As our mapping study aims at research gaps and trends, we investigated every possible relevant citation. In case the search terms were not explicitly stated in a paper, we could still incorporate articles that discussed several BPM(-related) concepts from an environmental sustainability perspective. At the other hand, other articles from related domains such as green supply chain management were excluded if they did not have a direct link with Green BPM. Afterwards, a quality assessment was conducted. We aimed at peer-reviewed papers to construct our sample. As we searched in academic databases the quality criteria were fulfilled. In sum, although the selection and quality criteria can be less stringent for mapping studies [53], the result of our search and selection procedure was a sample consisting of only high-quality, peer-reviewed journals and conferences to ensure academic quality.

Table 3. Overview of inclusion, exclusion and quality criteria.

Inclusion	Exclusion	Quality
One or a combination of search term(s)	Duplicates	Peer-reviewed
Indexed in the databases (i.e., automated search)	No direct link with Green BPM (capabilities)	
Detectable by citations (i.e., backward snowballing)		
From all periods until January 2019		
Written in English		

3.4. Extraction of Articles

An overview of our article extraction phase is given in Figure 2. The automated search generated 192 results that were investigated against the inclusion and exclusion criteria. This screening was based on the article's title, keywords, abstract and (in case of doubt) introduction and conclusion, resulting in 42 articles. Next, an extended search was conducted based on citations within this sample of 42 articles. By means of backward snowball sampling, other potential articles with a focus on Green BPM were listed, resulting in 164 additional papers that were investigated against the inclusion and exclusion criteria. Many of these articles came from related domains such as green supply chain management or green information systems. Similar to the primary articles, we selected articles having a direct link with Green BPM and considered 18 additional articles as relevant for this study. For these 18 articles, we repeated the backward snowball sampling, but no new articles focusing on Green BPM were found. Thus, the final sample for our research consisted of 60 articles. Appendix A provides access to the database with articles created for the analysis.

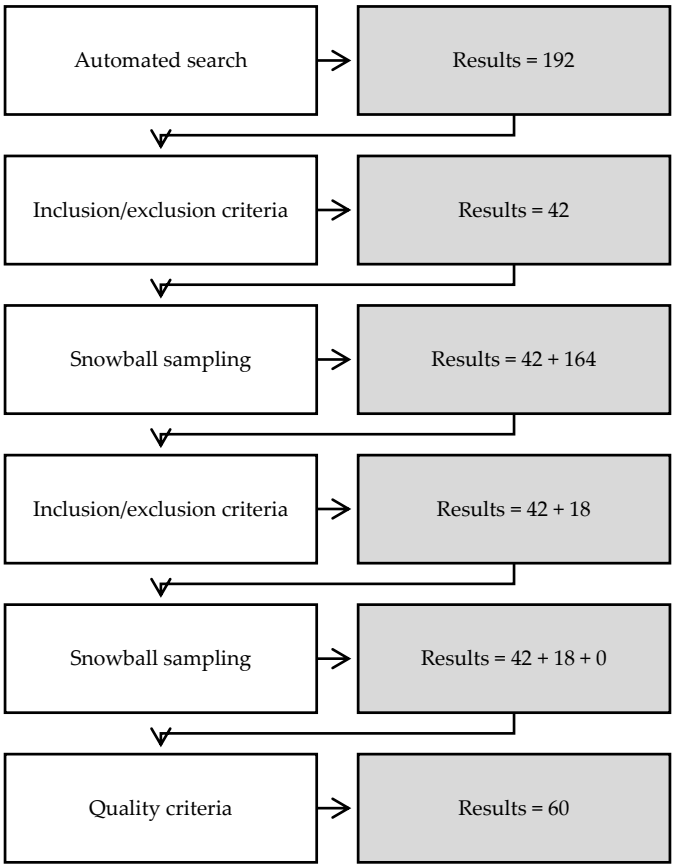


Figure 2. Number of included articles during the selection phase.

3.5. Creation of Classification Scheme

Based on the theoretical background (Section 2) and the scope of this study (Section 3.1), we now present the integrated classification framework. As indicated, classification schemes can be fixed or topic-driven [28]. As our goal is to present a comprehensive Green BPM research agenda relevant for both academics and practitioners, we first searched for a fixed classification scheme that can serve this objective. The dichotomy of research modes [25] was adopted as a fixed classification scheme to fulfill this requirement. Any research agenda for a particular discipline can be addressed by a dynamic Mode 1 and Mode 2 knowledge interaction to ensure both scientific and practical relevance.

Subsequently, we evaluated our sample of Green BPM literature for each Mode 1 attribute. These results provided us with research directives for Mode 1 but simultaneously enabled us to make research suggestions for Mode 2 applications. For each attribute of the dichotomy of research modes [25], we integrated Green BPM-relevant and topic-specific classifications. The proposed research questions in line with the five attributes facilitated the evaluation.

For the first attribute, RQ1 evaluates the scope of theory and knowledge within academia (Mode 1) and suggests Mode 2 applications. This evaluation was done by distinguishing between technical and managerial capabilities as outlined in the theoretical background (Section 2.3). RQ2 investigates the interdisciplinarity of Green BPM and proposes pathways to reach transdiciplinarity. We started from the three underlying process change traditions as described in Section 2.2. For the third attribute, RQ3 investigates the (accountability of) environmental problems addressed by Green BPM (Section 2.1). RQ4 investigates the researchers and research organizations involved in Green BPM and suggests ways to broaden cooperation between different partners. We specifically considered institutional affiliation and leading researchers. Finally, RQ5 evaluates the ways of academic dissemination and proposes novel quality control approaches. Table 4 summarizes the basic attributes for each mode of knowledge

production, along the proposed research questions to facilitate the construction of the research agenda and the related classification areas.

Table 4. Overview of Mode 1 and Mode 2 attributes, research questions, and classification areas.

Attributes	Mode 1	Mode 2	Research Questions	Classification Areas
(1) Scope	Rigorous and focused body of theory and knowledge	Relevant solution to a real-world problem	RQ1. Which capabilities are covered in Green BPM?	Technical and managerial capabilities
(2) Disciplines	Within discipline	Transdiscipl.: researchers and society stakeholders	RQ2. Which disciplines are involved in Green BPM?	Quality Control, Business Management, IS and BPM
(3) Accountability	Autonomous: within academic institutions	Reflexive: socially accountable to multiple stakeholders	RQ3. Which environmental problems are addressed by Green BPM?	Environmental topics
(4) Researchers	Homogen.: traditional academic institutions	Heterogen.: academic, business, government	RQ4. Which researchers are involved in Green BPM?	Institutional affiliation, leading researchers
(5) Quality	Academic: scholarly conferences and journals	Novel: practitioner conferences and platforms	RQ5. Which ways of dissemination are used in Green BPM?	Publication year and type

Transdiscipl. = transdisciplinarity; Homogen. = homogeneous; Heterogen. = heterogeneous.

4. Results

4.1. Results for RQ1: Scope

For RQ1, the sample of articles was analyzed to identify BPM-related capability areas across technical capabilities and/or managerial capabilities. The resulting classification framework is presented in Figure 3.

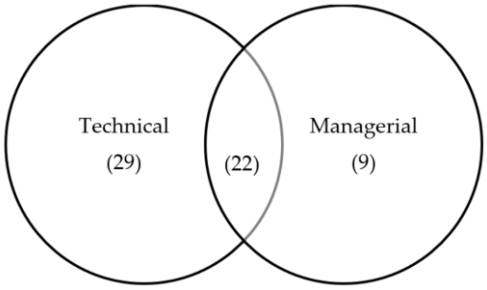


Figure 3. Number of articles per scope category (N = 60).

Figure 3 shows that 29 out of 60 articles were mapped as covering technical capabilities. These articles focused solely on the modelling, deployment and optimization of environmentally sustainable business processes. Nine articles were classified in the managerial category and solely focused on a particular management concept without discussing other capability areas. For instance, [58,59] explored the application of sustainability to project management. Finally, we classified 22 out of 60 articles in the intersection of both technical and managerial capabilities. Articles within this intersection

extended the rather technical business process lifecycle with a management dimension to achieve environmentally sustainable business processes. For instance, Ahmed and Sundaram [60] presented a sustainable business transformation cycle with five steps: "monitor and control", "discover and learn", "strategize", "design", and "transform".

4.2. Results for RQ2: Disciplines

We proposed four categories to evaluate the disciplines related to Green BPM. These categories were the process change traditions as outlined in the theoretical background (Section 2.2) and a comprehensive BPM approach that evolved out of these underlying traditions [18]. In order to map the sampled articles to these categories, we screened all 60 papers for Green BPM definitions. Figure 4 presents the total number of articles for each discipline.

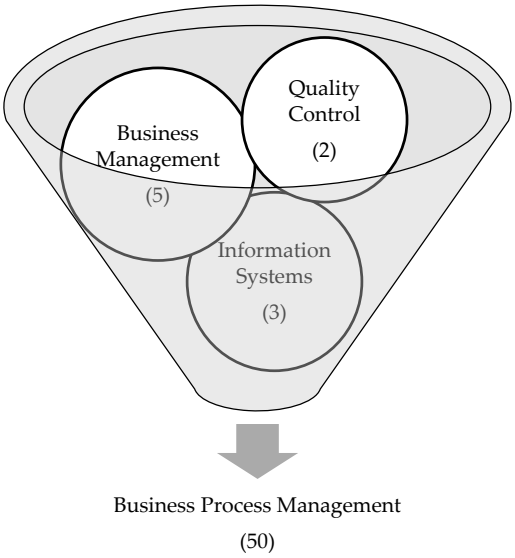


Figure 4. Number of articles per discipline (N = 60).

We uncovered that the three process traditions underlying BPM [18] remain important in current Green BPM studies. For instance, two articles strongly relied on the Quality Control tradition. They proposed a CMM for corporate sustainability [19] and ICT sustainability [61]. The same holds for the Business Management tradition. Zeise et al. [20] presented performance measurement systems for sustainable companies (e.g., Sustainability Balanced Scorecards). Other articles discussed sustainable business transformation [60], supply chains [62] or project management [58,59]. Regarding the IS tradition, three articles reflected on the inevitable role for IS [5,8,63]. However, the majority of sampled articles adopted IT to support process-oriented techniques.

In 50 out of 60 articles, we found more evidence of Green BPM as an interdisciplinary approach. Such articles simultaneously addressed aspects from the three BPM traditions. For instance, Nowak et al. [2] presented a holistic Green BPM approach by first introducing a conventional business process lifecycle (i.e., relying on the Quality Control and IS traditions) before using the value chain of Porter (i.e., from the Business Management tradition) to identify Green BPM business requirements. In some articles, the interdisciplinary approach was literally stated. For instance, Dao et al. [64] developed a sustainability framework "*illustrating the integration of human, supply chain, and IT resources to develop sustainability capabilities*" (p. 63).

4.3. Results for RQ3: Acccountability

To evaluate research accountability in RQ3, we screened the sample on sustainable topics by relying on Elkington's [30] sustainability dimensions for differentiating general environmental concerns from specific goals (Figure 5).

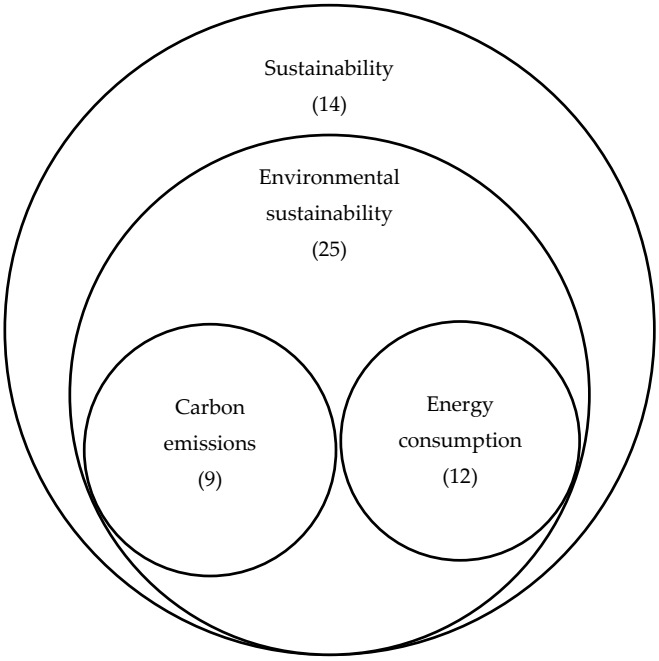


Figure 5. Number of articles per environmental topic (N = 60).

We initially observed 17 articles using the term "sustainability" as the focus of their study. However, three of them [61,65,66] discussed "environmental sustainability" without considering the social and economic dimensions as proposed by Elkington [30]. This means that 14 out of 60 Green BPM articles examine "sustainability" in line with Elkington's TBL [30]. The other 46 articles associated Green BPM with environmental considerations. From these 46 articles, 25 papers stated general environmental objectives (e.g., reducing the environmental harmful effects of business processes). Concerning more specific environmental topics, nine articles specifically studied the reduction of carbon emissions and 12 articles focused on the reduction of energy consumption.

4.4. Results for RQ4: Researchers

Attribute 4 of the classification framework presented in Table 4. evaluates the researchers involved in Green BPM. Overall, we counted 183 authors and co-authors in our sample. We investigated the researchers' institutional affiliation, which confirmed that a vast majority is involved in academics (173). A minority of researchers work for businesses (7) or governments (3). Figure 6 summarizes these findings.

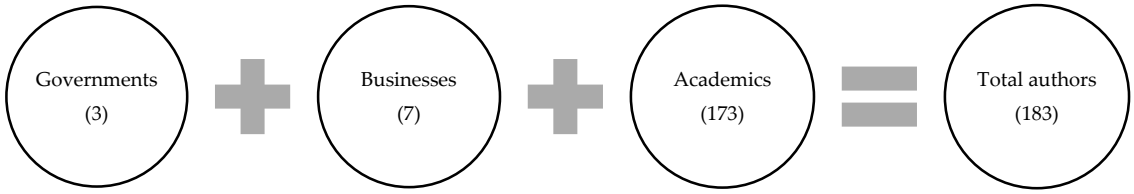


Figure 6. Number of authors per institutional affiliation (N = 183).

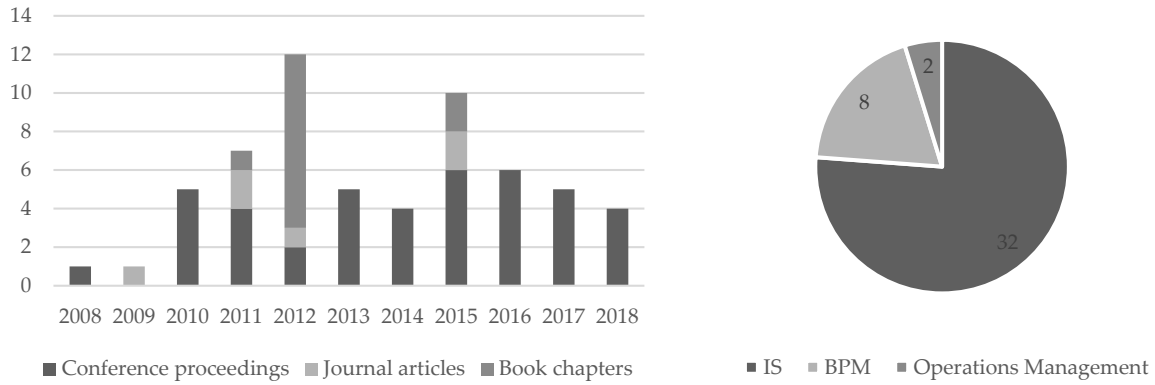
Table 5 presents the leading authors (i.e., more than three articles) within the Green BPM discipline along with their total number of publications. Although not presented in Table 5, two other important authors in the Green BPM discipline are also worthwhile to mention, namely Seidel and vom Brocke. Both authors have two articles but, together with Recker, they have co-edited a book on Green BPM [17]. From this book, we retrieved nine chapters as relevant for our study.

Table 5. Total publications per leading author.

Author	Publications
Fettke	7
Loos	6
Ghose	5
Hoesch-Klohe	5
Leyman	5
Lübbecke	5
Nowak	5
Recker	5
Betz	4
Kollbe	3
Opitz	3
Reiter	3

4.5. Results for RQ5: Quality Control

We continued to analyze the different ways of dissemination (Figure 7). From 2008 until 2018, 12 out of 60 contributions were issued as a book chapter. Nine out of 12 chapters were published in a book on Green BPM by vom Brocke, Seidel and Recker [17]. Journal publications were limited (6). Most sampled articles (i.e., 42 out of 60 papers) were conference proceedings. The International Conference on Business Process Management (BPM) was leading with eight papers. Two papers were presented on conferences in the field of operations management. We noticed that 32 out of 42 papers were presented on IS-related conferences. As four out of six journal publications also concerned IS journals, we conclude that BPM platforms are less preeminent ways of dissemination so far.



(**a**) (**b**)

Figure 7. Overview types of scholarly dissemination. (**a**) Academic dissimination (N = 60). (**b**) Conference proceedings (N = 42).

5. Discussion: Research Agenda

Figure 8 presents our resulting research agenda for Green BPM per attribute and along the dichotomy of research modes [25,26]. Although represented as a figure here, the classification framework(s) presented in Table 4 can be recognized. Similar to Table 4, each attribute of the dichotomy of research modes [25] is represented on a row. The Green BPM topic-specific classifications discussed in the theoretical background (Section 2) and presented in Table 4, are also presented on Figure 8. More specifically, for the attribute of (1) scope, the distinction between technical and managerial capabilities is given, whereas the attribute of (2) disciplines shows information on other research areas and process traditions, and the attribute of (3) accountability presents environmental topics. For the attributes of (4) researchers and (5) quality control, results from the bibliometric analysis are included. For each attribute, the actual Mode 1 evidence is presented by white circles, while future Mode 1

avenues are indicated by grey circles. Alternatively, Mode 2 applications are presented by dashed circles in Figure 8. Arrows represent interactions between Mode 1 and Mode 2 in order to let Green BPM advance as a dynamic business-oriented discipline. For instance, with regard to the Green BPM scope on the first row, we found more evidence on technical than on managerial capabilities and we therefore advise to focus further research on managerial capabilities. We also recommend practitioners to adopt the current theory and knowledge and to contribute to further development of technical and managerial Green BPM capabilities. The five attributes are subsequently discussed. We also elaborate on additional contributions from the practitioner community.

5.1. Scope

We evaluated the Mode 1 theory against two areas of BPM development, namely technical and managerial capabilities. Based on RQ1, we conclude that Green BPM research has focused more on technical than managerial capabilities. It seems that Green BPM follows a similar evolution as the BPM discipline since early BPM research also mainly focused on technical capabilities [13]. This implies a potential for further research on managerial capabilities. For instance, ecological values and employee behaviors are only briefly discussed. Also other topics such as environment-friendly appraisals and rewards, and top management commitment should be investigated in more detail.

Although Mode 2 knowledge occurs in a context of application, we believe that the existing body of Mode 1 research can be adopted by practitioners. For instance, the literature on technical capabilities can be applied within organizations. Furthermore, the managerial idea of a "Sustainability Board" as a new governance body can be implemented at the company level. Although the theoretical body of Mode 1 research is not yet complete, there is already a profound base for adoption.

The technical and managerial categories are also covered by Green BPM contributions from the practitioner community (i.e., Mode 2). Further Mode 1 research can elaborate on these ideas. For instance, with regard to technical capabilities, Harmon [67] suggested that System Dynamics can be a valuable tool for greening the company's processes. System Dynamics is an approach to simulate situations in which a large number of variables interact. Alternatively, an ecological analysis can be proposed concerning a company's value stream [68]. In addition to the typical value-add analysis, Harmon [68] pledged to extend the scope with an energy-add or waste-add analysis. Regarding managerial capabilities, we found concrete guidelines for employees. Harrison-Bronski [69] proposed to travel less and to replace face-to-face meetings with video-conferences. Sinur [70] advocated to drastically reduce the use of paper. For the company structure, Harmon [23] stated that every company should have an environmental team, working very closely with the BPM team.

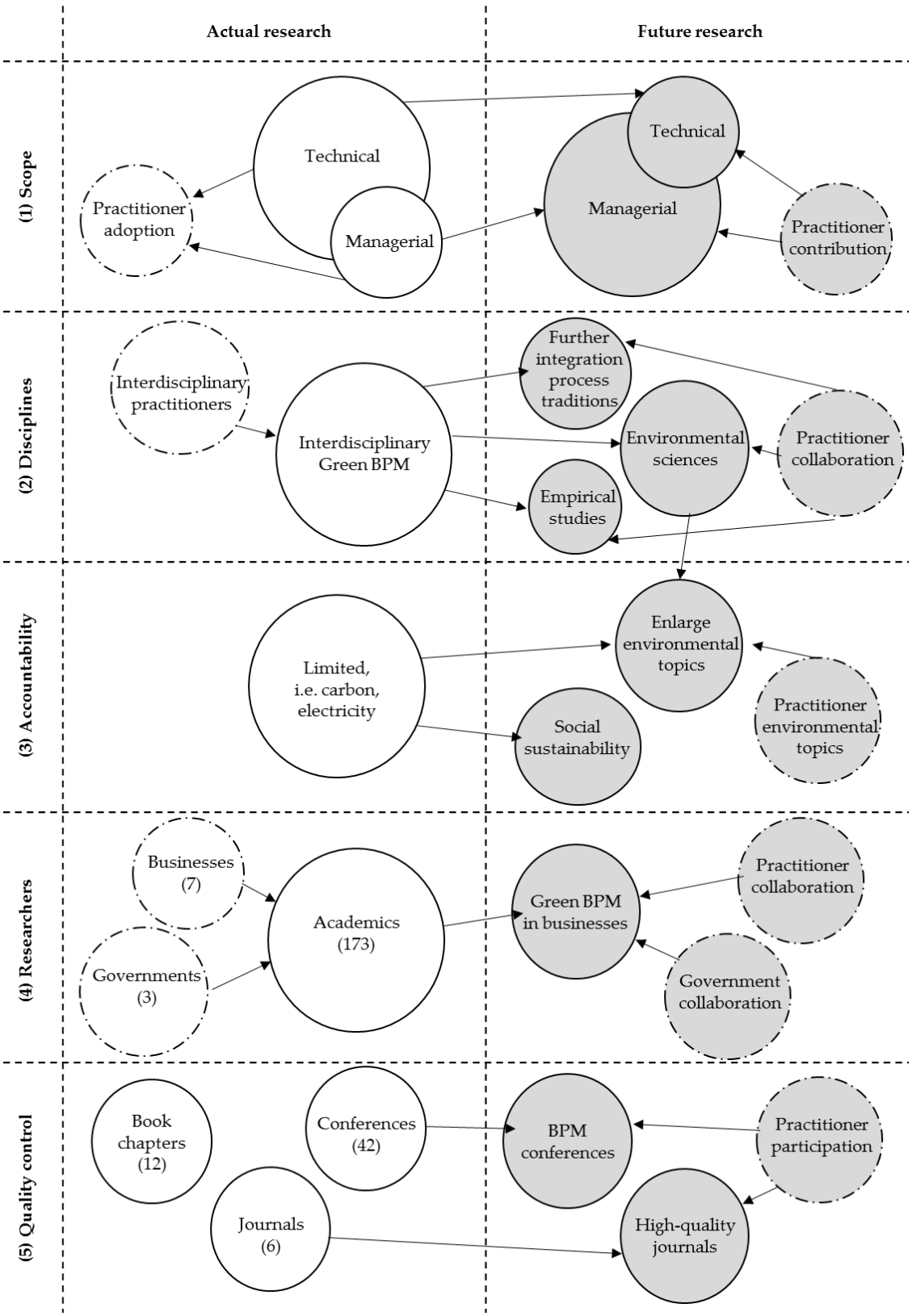


Figure 8. Green BPM research agenda based on dichotomy of research modes.

5.2. Disciplines

We noted different attitudes related to the underlying BPM traditions, and in particular towards Green BPM methods and techniques. We found some studies were relying too much on one particular tradition (e.g., through IT adoption). However, evidence is provided that Green BPM requires a coverage of multiple disciplines. For instance, Green BPM (and BPM in general) are broader than IT-applications and have more to offer than merely the optimization of IT-enabled processes.

Nonethless, from RQ2, we conclude that a significant majority of researchers agreed on Green BPM as an interdisciplinary approach. We identified frameworks, concepts and techniques from different process change traditions evolving in a comprehensive Green BPM approach. This also offers opportunities for further research. For instance, well-established optimization methods such as Lean or Six Sigma (i.e., Quality Control tradition) were absent in our sample. Although some literature on these topics and environmental sustainability exist [71,72], the Quality Control topics are insufficiently incorporated in the field of Green BPM. Hence, to further develop Mode 1 research, we advocate the involvement of research participants from the different Green BPM traditions, and especially from the still under-respresented Quality Control and Business Management traditions.

Besides the process change traditions, a substantial amount of knowledge on ecological topics lies in environmental sciences. Research participants of these disciplines can likewise enhance the Green BPM field. For instance, researchers focusing on waste management [73] and packaging life cycle assesment [74] can deliver valuable contributions to the Green BPM research area.

With respect to Mode 2 research, Green BPM shows a tendency towards a transdisciplinary field, but more practical evidence is required to confirm this. Transdisciplinarity goes beyond interdisciplinarity in the sense that once theoretical consensus is attained, it cannot easily be reduced to disciplinary parts. Our sample covered some articles with a holistic Green BPM approach, but these approaches were not validated by practical methodologies such as case studies and the practitioner community was not involved. Therefore, we strongly encourage Mode 1 researchers to work on empirical studies because Green BPM as a future transdisciplinary field requires a close collaboration with practitioners.

5.3. Accountability

With regard to concrete environmental topics, we conclude that Green BPM has currently focused on the reduction of carbon emissions and energy consumption. Given the wide variety of environmental topics that can be studied at the organizational level [31], Green BPM research needs to incorporate more topics in order to be considered as an accountable discipline. This can be stimulated by our call for participants from environmental sciences (as discussed in Section 5.2).

Moreover, compared to Mode 1, Mode 2 knowledge rather involves a dialogue including the capacity to incorporate multiple views. While emissions or energy efficiency are relevant environmental topics, we advise Mode 1 researchers to incorporate issues apparent from Mode 2 knowledge production. For instance, in the practitioner literature, authors have addressed other environmental problems such as business travels [69], paper consumption [70] and water drought [23]. As Mode 2 knowledge production is typically more "socially accountable", it can provide relevant environmental topics for Mode 1 as well. As the environmental deterioration concerns the society at large, a continuation of the Mode 2 dialogue is of crucial importance.

Finally, Elkington's TBL [30] is mainly addressed by the existing approaches on the economic and environmental dimensions. A full integration of Elkington's TBL [30], however, also requires research on the social dimension. To the best of our knowledge, we are not aware of literature on social sustainability in the context of BPM. We specially encourage research about well-being at the work place or professional development. Nonetheless, the current interpretation of social BPM is limited to business improvements through BPM techniques and Web 2.0 social tools [75].

5.4. Researchers

Since our sample was extracted from academic databases, researchers were mainly engaged in traditional universities (173). Nonetheless, we also identified authors working for businesses (7) and governments (3). Although the Mode 1 research is mainly performed by academics, Green BPM as an applied discipline typically investigates organizations as primary research subjects. Although it is relevant to investigate (the interest in) Green BPM practices, these types of studies were limited in our sample [21,22].

A further development of the Green BPM discipline requires contributions or initiatives by the practitioner community as well. We found evidence of practitioners contributing to Green BPM on the BPTrends platform. An interesting finding is that the term "Green BPM" was used on the BPTrends platform [70] even before it was introduced into academia in 2008 [76].

Also, cooperation with governments can further develop Green BPM. For instance, the idea of a circular economy is currently promoted by several governments. This is apparent from policies such as the European Circular Economy package [77] and the Chinese Circular Economy Promotion Law [78]. Geissdoerfer et al. [79] defined a circular economy as: *"a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling"* (p. 759). The terms used in this definition can be related to a Green BPM approach. At the organizational level, a circular economy implies that the outputs of business processes can become new inputs for the same or other business processes. Currently, a lot of research on this topic is performed from a macro-economic point of view. Green BPM can, however, deliver significant contributions to this debate from a micro-economic perspective as well. Such an adoption to the micro level is, for instance, supported by a report of McKinsey, entitled: "The Circular Economy: Moving from Theory to Practice" [80].

5.5. Quality Control

Finally, in line with the Mode 1 research tradition, our sampled Green BPM articles were disseminated through scholarly conferences (42), journals (6) and book chapters (12). The relatively higher number of conference proceedings (i.e., in contrast to the lower number of journal publications) can be explained to some extent by the shorter publication cycles for most conferences. Nonetheless, we evoke to concentrate more on Green BPM in order to deliver high-quality journal publications. Moreover, we uncovered that only eight out of 42 papers were presented on BPM-specific conferences, indicating that Green BPM should receive more attention in dedicated outlets in which process-centered techniques and a comprehensive approach towards Green BPM will be central.

Regarding Mode 2, the identified academic conferences, journals and books can be valuable sources for practitioners. Similarly, BPM academics can attend practitioner-based symposia or conferences. Since Green BPM contributions are also disseminated on practitioners' platforms (e.g., BPTrends), future Mode 1 research can also rely on these contributions.

5.6. Honeycomb of Green BPM Characteristics and Practical Implications

Besides offering a research agenda with the above-mentioned calls to action, this work intends to better position Green BPM as a holistic approach. For this purpose, the five attributes guiding our systematic mapping also serve as Green BPM characteristics from which practical guidelines can be derived. We refer to a honeycomb because the five attributes constitute the building blocks that need to be glued together in order to obtain a comprehensive Green BPM field. In particular, Figure 9 proposes a double honeycomb by directly translating the Green BPM characteristics into their respective practical implications.

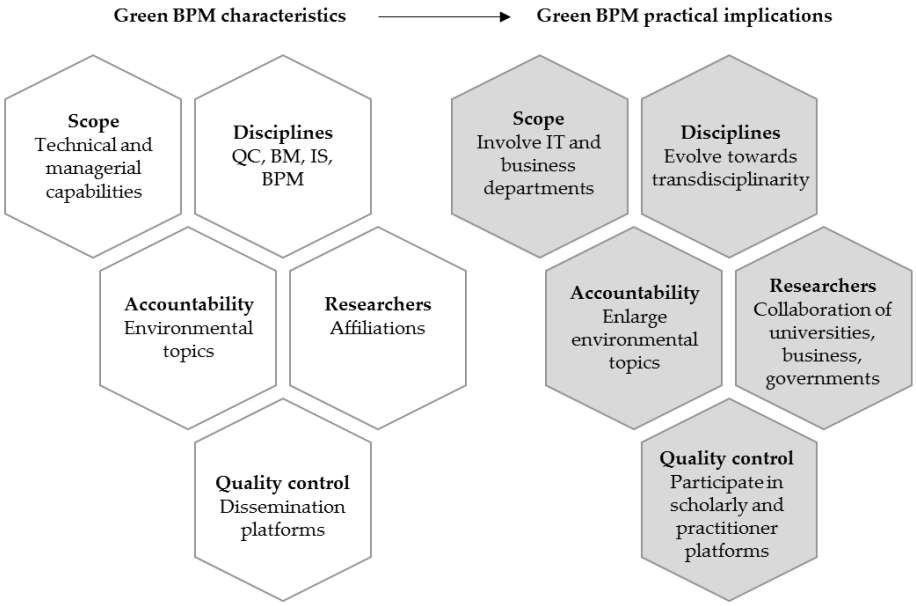


Figure 9. Honeycomb of Green BPM characteristics and practical implications.

Firstly, to let organizations advance in Green BPM practices, managers should involve both IT and business departments to enlarge their scope of Green BPM. This will ensure a further development of technical as well as managerial capabilities within the organization. Secondly, managers can foster Green BPM's transdisciplinarity by collaborating with academics and practitioners from different disciplines. A continuous collaboration between different disciplines will result in ecological process-centered techniques that cannot easily be reduced to disciplinary parts. Thirdly, the scope of environmental topics can be broadened. Incorporating an environmental sustainability perspective in the wide range of business activities will increase Green BPM's accountability. Fourthly, a further development of the Green BPM discipline requires cooperation between universities, businesses and governments. Managers can adopt Green BPM techniques developed in academia and more importantly, set up cooperation for the development of further techniques. Finally, as BPM academics can attend practitioner-based symposia or conferences, the identified academic conferences, journals and books can also be valuable sources for managers and their organizations.

6. Conclusions

Although we have carefully constructed the research agenda, we acknowledge some limitations related to the applied systematic mapping methodology. Since subjective decisions could have been typically made when selecting the studies, we have followed a protocol with defined steps and the researchers' interpretation is inherent to the application of the inclusion/exclusion criteria. A similar reasoning also holds for the classification, and therefore the principal researcher minimized these possible errors by performing such tasks in several iterations. The sample and classification of literature was also revised multiple times as our understanding of the Green BPM field evolved. Moreover, the second researcher offered critical comments throughout this entire study (i.e., as from the early stages onwards). Finally, we note that this study is limited to the applied search strings, search databases and an upper time limit of January 2019. Nonetheless, by relying on multiple literature reviews for the search terms [6–9], on the selection of seven leading academic databases and on the application of backward snowballing, we endeavored the objective to capture all possible research gaps and trends.

Despite these limitations, this study has positioned Green BPM as an interdisciplinary field by conducting a systematic mapping study. The work was inspired by a dichotomy of research modes to bridge the current rigor-relevance gap, and the five derived attributes resulted in different

classifications of current Green BPM literature. The results have been bundled in a research agenda with a varied set of calls to action to let the Green BPM field advance in terms of its (1) scope, (2) disciplines, (3) accountability, (4) researchers and (5) quality control. Meanwhile, the required Green BPM characteristics have been translated into a honeycomb with practical guidelines for managers to let their organizations advance in Green BPM practices.

Our focus on the rigor-relevance gap and the proposed practical guidelines makes the research agenda relevant for both academics and practitioners. Gaps and recommendations for further academic research in Green BPM are clarified. Simultaneously, practitioners can check if current theory and knowledge are relevant to them for delivering practically useful results while they can also contribute to help progress Green BPM developments by providing feedback. With this dynamic interaction of knowledge systems, we provide a basis to let Green BPM advance as an applied and business-oriented discipline.

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Appendix A

We provide an access link to the database created for the analysis of the literature systematic mapping: https://docs.google.com/spreadsheets/d/1CtrxCdQ8tfvE9eZgLR9duhomrkAahGhVRnJeKu_Tbwc/edit?usp=sharing.

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