The Core Capabilities of Green Business Process Management – A Literature Review

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1 PUBLICATION   **28** CITATIONS

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Abstract. Environmental sustainability has become a key concern of contemporary organizations, due to the impact of their operations on the environment. Organizations can be seen as sets of business processes that aim to generate business value, and business process management can play a significant role in designing and implementing more environmentally sustainable processes. Green BPM is the discipline that integrates sustainability-related thinking into business process management. In this paper, we present the results from a literature review on Green Business Process Management. Using the six core elements of BPM – Strategic Alignment, Governance, Methods, Information Technology, People, and Culture – as an analytical lens, we identify key capabilities required in Green BPM. Based on our analysis, we derive a Green BPM lifecycle to identify relevant methods, techniques, and approaches that can be applied to help organizations design improved business processes that exert a minimal impact on the natural environment.

Keywords: Green BPM, Environmental Sustainability, Core Elements of BPM, Green BPM Lifecycle, Literature Review.

1 Introduction

Environmental Sustainability is one of the various concerns of contemporary organizations, and sustainability is now often seen as an explicit performance dimension, in addition to traditional ones such as cost, time, and quality [1]. Sustainability has become increasingly important as organizations need to comply with rules and policies with regards to their operations and their consequences on the natural environment [2].

Organizations can be seen as sets of business processes operating to generate business value. The enterprise's business processes play an important role in contributing to the carbon footprint an organization emits [3]. Therefore, as BPM focuses on the understanding and improvement of an enterprise's business processes [4], it can be a significant enabler towards more environmentally sustainable organizations. Furthermore, Green BPM is the discipline that integrates sustainability-related thinking into business process management.

In this paper, we present the results from a literature review on Green Business Process Management. Prior literature reviews on the topic can be found [5], [6], [7]. However, this study takes into account a different approach to analyze the current state of Green BPM research. Using the six core elements of BPM [8] – Strategic Alignment, Governance, Methods, Information Technology, People, and Culture – as an analytical lens, we identify key capabilities required in Green BPM. This study also differs from previous literature reviews as it depicts a Green BPM lifecycle, which encompasses diverse methods and techniques derived from the literature. Our essential research question is:

What is the current state of Green BPM research?

The remainder of this paper is structured as follows. Section 2 provides an overview on the concepts of Green BPM and green business process, as well as on the six core elements of BPM. Section 3 describes the methodology used for the literature review. Section 4 presents the main findings from the analysis of the literature. Section 5 presents the Green BPM lifecycle derived from literature. Potentials for future research are disclosed in Section 6. Finally, Section 7 concludes with a summary of the results.

2   Research Background

2.1   What is Green BPM?

We firstly present the concepts of sustainability and BPM, which are followed by a definition of Green Business Process Management. Sustainability is commonly defined as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [9]. Business process management can be defined as the discipline that provides appropriate concepts, methods, and tools to model, implement, operate, and monitor business processes [10]. Different yet similar definitions of Green BPM can be found. They commonly build on the business process lifecycle from "classical" BPM, and add the ecological factor. Examples are the "dedicated consideration paid to the environmental consequences of these business processes" [11], the optimization of business processes considering the ecological dimension [12], and the aim to support environmental objectives [13].

Thus, one can understand Green BPM as the discipline that provides appropriate concepts, methods, and tools to support business process modeling, implementation, execution, monitoring, and continuous change with dedicated consideration of the environmental impact of these business processes.

2.2   What is a Green Business Process?

The execution of a business process has always a certain impact on the environment [12]. Business processes play thus an important role in contributing to the carbon footprint of an organization [3]. As a business process transforms inputs into outputs,

the renewable and non-renewable inputs as well as the type and environmental quality of the outputs determine the sustainability of a business process [14]. In this line of thought, the extent of renewable inputs as well as the extent of emissions (outputs) that can be kept within the assimilative capacity of the environment should be maximized, while the extent of non-renewable inputs and the extent of emissions (outputs) that exceed the assimilative capacity of the environment should be minimized [14].

Therefore, a green business process is an environmentally conscious business process that is necessary, efficient, effective, agile, and measurable in the context of an organization [3] and delivers organizational value with a minimal impact on the natural environment [14]. Additionally, from a more technological perspective, an energy-aware business process is a service-based business process that considers functional and non-functional requirements, as well as specific annotations for guiding energy assessment [15].

In summary, one can understand that an environmentally sustainable (green) business process is a business process that generates business value with minimal impact on the environment, thus without compromising the environmental resource availability for future generations.

2.3   The Six Core Elements of Business Process Management

In this study, we consider the model of BPM capabilities [8] (Table 1) to analyze the literature on Green BPM in terms of its contributions related to the six core elements of BPM: strategic alignment, governance, methods, information technology, people, and culture. This model seems very appropriate for this study as all these elements represent critical success factors for BPM in an organization [8]. Therefore, each element should be considered by organizations seeking success with BPM [8]. For each element, distinct capability areas were identified, as shown in Table 1. The six core elements can be described as follows [8]:

- **Strategic Alignment**: The complete cycle of BPM needs to be tightly linked with the overall strategy of the organization, enabling continuous improvement and achievement of business goals.
- **Governance**: BPM Governance establishes pertinent and straightforward accountability for different levels of BPM. In addition, it provides support to the design of decision-making and compensation processes to manage process-related actions in business process management.
- **Methods**: Set of instruments and techniques that enable and support consistent actions along the BPM lifecycle.
- **Information Technology**: IT-based solutions are the software, hardware, and information systems that enable and support BPM activities.
- **People**: Individuals and groups who continuously develop and apply their BPM-related skills and knowledge in order to enhance business performance.
- **Culture**: Culture is the collective beliefs and values that define BPM-related attitude and behavior in order to enhance business performance.

Table 1. The six core elements of BPM [8]

Strategic Alignment	Governance	Methods	Information Technology	People	Culture
Process Improvement Planning	Process Management Decision Making	Process Design & Modeling	Process Design & Modeling	Process Skills & Expertise	Responsiveness to Process Change
Strategy & Process Capability Linkage	Process Roles and Responsibilities	Process Implementation & Execution	Process Implementation & Execution	Process Management Knowledge	Process Values & Beliefs
Enterprise Process Architecture	Process Metrics & Performance Linkage	Process Monitoring & Control	Process Monitoring & Control	Process Education	Process Attitudes & Behaviors
Process Measures	Process-Related Standards	Process Improvement & Innovation	Process Improvement & Innovation	Process Collaboration	Leadership Attention to Process
Process Customers & Stakeholders	Process Management Compliance	Process Program & Project Management	Process Program & Project Management	Process Management Leaders	Process Management Social Networks

3 Methodology

We conducted a structured literature review [16] to answer our research question presented in Section 1. The subject of this literature review is environmentally sustainable business process management. Therefore, the search terms were "Green", "Sustain*", "BPM", "Business Process Management", "Business Process", and "Process". *Google Scholar* was the main search engine used for the literature search, but *ScienceDirect* and *ABI/INFORM Complete* were also considered to corroborate the search process. The terms *Green IT* and *Green IS* were excluded from the search, since we aimed to find BPM-related papers exclusively. Initially, we retrieved 52 papers that we considered relevant for this study based on their title and abstract. However, we did not have access to full-text of ten papers, thus these ones were excluded for further analysis. The final set contained 42 articles selected for deeper analysis, as they were identified to be relevant to our study, and we had access to their full content.

Based on the framework described on the previous section, we classified the literature according to its main coverage content. For each source, the categorization took into account frameworks, models, and propositions related to Green BPM. A paper that, for instance, simply mentions that strategic alignment is important in BPM, or that Information Technology plays a critical role in delivering process innovation, would *not* be categorized in the Strategic Alignment and Information Technology capability areas, respectively.

4   Findings

The analysis of the literature led us to two main categories of papers: (i) papers that provide a more general view on Green Business Process Management (10), such as literature reviews, or papers presenting holistic approaches covering many aspects of business process management; and (ii) papers with a focus on one or more specific areas of interest for Green BPM (32). Additionally, 67% of the papers analyzed were conceptual in nature.

The papers classified as *General* present: (i) differences and commonalities between green and conventional business process management [2]; (ii) a literature review on Green BPM [5]; (iii) a literature review and research framework for Green BPM [6]; (iv) a literature review on Green BPM [7]; (v) an introduction to and a framework for Green BPM research and practice [11]; (vi) an approach that utilizes a BPM framework in order to transform and manage business processes for a Green Telecommunications company [17]; (vii) ways to manage sustainability in the face of unordered business processes [18]; (viii) opportunities and challenges of Green BPM based on conceptual considerations [19]; (ix) a Green BPM readiness model [20]; and (x) the role of business process management in green initiatives [21].

With regards to the core elements of BPM, this study shows that most of the papers (54%) are focused on *Methods* (See figure 1). *Methods* and *Information Technology* together represent more than 80% of the literature. Our analysis thus shows that Green BPM research has been mainly focusing on the process lifecycle, aiming to find answers related to issues in the design, measurement, and improvement of processes in terms of environmental sustainability.
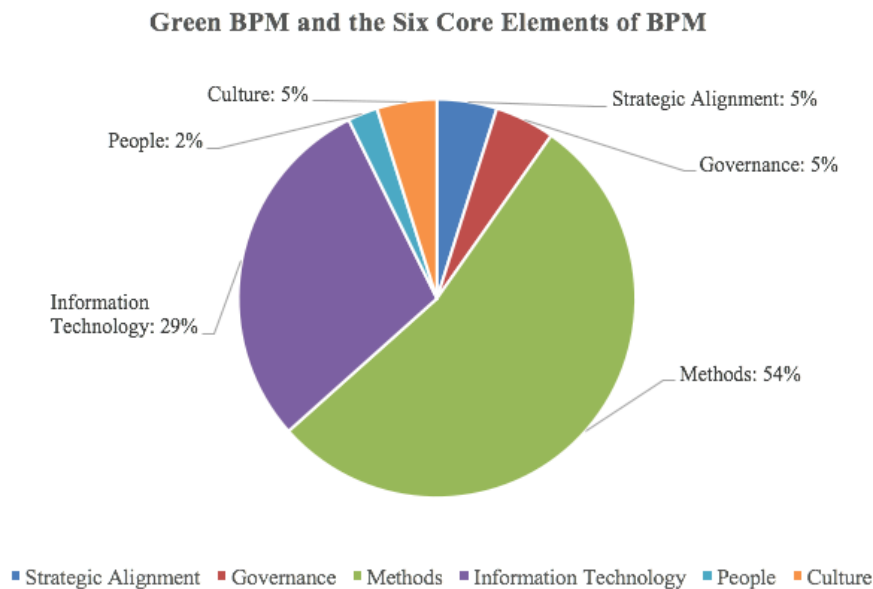
Figure 1. Green BPM Research on the lens of the six core elements of BPM

Table 2. (Green) Strategic Alignment

Topic	Authors
Business Motivation Model	[22]
Green Performance Indicators (GPIs)	[15]
Key Ecological Indicators	[2], [23], [24], [25]
Sustainability Indicators	[26], [27]
Process Architecture	[22]
Sustainability Balanced Scorecard (SBSC)	[28]

Table 3. (Green) Governance

Topic	Authors
Roles and Responsibilities	[2]
Process Performance Management	[29]
Process-related Standards	[30]

Table 4. (Green) Methods

Topic	Authors
Green Business Process Patterns	[12], [25], [31], [32]
Annotations	[15], [33]
Emission Annotations	[4], [34]
PMapping extension	[35]
Extensions of process modeling notations	[26], [36], [37]
Evaluation of process modeling notations	[38]
Activity-Based Emission (ABE)	[36], [39]
Green Activity Based Management (ABM)	[40]
Process Viewing Patterns	[24]
Enterprise Topology Graph (ETL)	[25]
Business Process Simulation	[26], [37]
Process SEER	[4], [34]
Abnoba Framework	[2], [5], [28], [41]

Table 5. (Green) Information Technology

Topic	Authors
Sustainability aware software system engineering framework	[27]
Evaluation of process modeling tools	[38]
Functional affordances of information systems	[14]
Energy Informatics	[42]
Process Mining	[13]
Geographic Information Systems (GIS)	[33]

Topic	Authors
New functionalities for process modeling and analysis tools	[34]
Process Simulation tools	[13]
Process Automation	[12]
IT solutions for Process Monitoring & Control	[25]
Energy-aware business processes	[15]
Conceptual integration model for the energy consumption of business processes, applications, and IT devices	[10]
Semantic Process Benchmarking	[43]
Cloud Patterns	[23]

Table 6. (Green) People

Topic	Authors
Collaborative Green Business Process Management	[44]
Process Education	[3]

Table 7. (Green) Culture

Topic	Authors
Responsiveness to process change	[45]
Process attitudes and behaviors for small and medium enterprises	[46]

5   Green BPM and the Process Lifecycle

Based on the literature review, we derived a **Green BPM lifecycle** (Figure 2 - adapted from [47]), which considers the methods, techniques, and approaches yielded through our literature analysis. The model represents a non-exhaustive rack of items found in the literature. This lifecycle model thus identifies which methods, techniques, and approaches might be selected and combined according to the specific business context, and under consideration of the environmental, process-related goals of an organization. Some of the methods present in the lifecycle (e.g. Process Viewing Patterns, process automation) are not exclusively designed for Green BPM. Nonetheless, we assume that, whether combined with other techniques or not, they might support the overall enterprise-wide process management framework, thus being able to contribute to making business processes more environmentally sustainable. We believe that the Green BPM lifecycle can serve as a framework for future studies in this field, and we thus encourage its empirical application and evaluation.
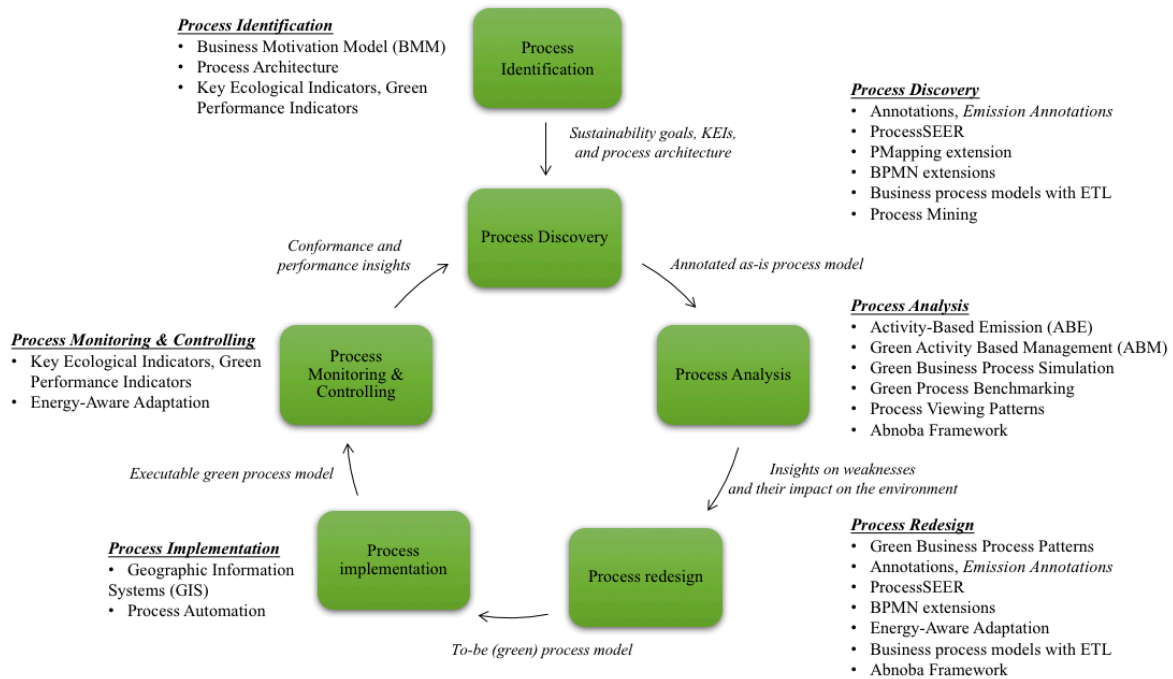
Process Identification
- Business Motivation Model (BMM)
- Process Architecture
- Key Ecological Indicators, Green Performance Indicators

Process Discovery
- Annotations, *Emission Annotations*
- ProcessSEER
- PMapping extension
- BPMN extensions
- Business process models with ETL
- Process Mining

Process Analysis
- Activity-Based Emission (ABE)
- Green Activity Based Management (ABM)
- Green Business Process Simulation
- Green Process Benchmarking
- Process Viewing Patterns
- Abnoba Framework

Process Redesign
- Green Business Process Patterns
- Annotations, *Emission Annotations*
- ProcessSEER
- BPMN extensions
- Energy-Aware Adaptation
- Business process models with ETL
- Abnoba Framework

Process Implementation
- Geographic Information Systems (GIS)
- Process Automation

Process Monitoring & Controlling
- Key Ecological Indicators, Green Performance Indicators
- Energy-Aware Adaptation

Lifecycle nodes: Process Identification → Process Discovery → Process Analysis → Process redesign → Process implementation → Process Monitoring & Controlling

Arrows:
- *Sustainability goals, KEIs, and process architecture*
- *Annotated as-is process model*
- *Insights on weaknesses and their impact on the environment*
- *To-be (green) process model*
- *Executable green process model*
- *Conformance and performance insights*

Figure 2. Green BPM lifecycle (Adapted from [47])

6   Research Agenda

From the literature analysis, we found several approaches that integrate sustainability-related thinking into business process management. Since most of the papers are conceptual, we believe that future research should focus on empirical studies that propose and evaluate methods, techniques, and initiatives that can be applied to all six core areas of BPM, and that can support organizations in the execution of business processes leading to as little impact as possible on the natural environment.

Strategic Alignment is mostly considered in terms of *Process Measures*, with environmentally sustainable performance indicators [2], [15], [23], [24], [25], [26], [27]. However, little or no attention has been paid to the other capability areas within this core component of BPM (e.g., process improvement planning, etc. – see Table 1). Future studies might focus on the alignment of Green BPM with the overall strategy of an organization. So, how could organizations address the trade-off between economic and environmental goals in their strategy? How to consider environmental characteristics of processes in the *Enterprise Process Architecture*? Which sustainability factors should be acknowledged in a *Process Improvement Plan*?

We found several **Methods** that can support the adoption of Green BPM and help organizations reduce the negative impact of their business processes. Nevertheless, there was no paper classified in the *Process Program & Project Management* capability

area, and little attention has been paid to *Process Implementation & Execution*. So, how can sustainability factors be embedded into executable business process specifications? Which methods and approaches should be used for the management of green BPM projects?

Even though some relevant research on **Information Technology** as an enabler of Green BPM exists, there is still a lack of explicit focus on the process lifecycle. This is the case, for example, of process modeling tools that incorporate green process modeling notation extensions (e.g. BPMN, EPC) or BPM systems that consider ecological characteristics. How should these extensions be described in order to facilitate their implementation by BPM software vendors? Which tools could facilitate the management of green initiatives? We strongly encourage more in-depth research on solutions that support the mining, modeling, analysis, simulation, implementation, and monitoring of green business processes, thus providing means of integration and incorporation of sustainability factors within those information systems.

Our analysis indicates that research has paid little attention to **Governance, People,** and **Culture** in green business process management. We thus argue that there is still a need for studies on Green BPM that address these areas in more detail. In the context of *Governance,* what would be appropriate methods to measure an organization's Green BPM maturity? How to design structured and consistent decision-making processes to guide sustainability-related actions? When considering *People*, what are the *Process Skills and expertise* necessary in a sustainable BPM approach? For *Process Education* initiatives, what needs to be considered in a Green BPM education curriculum? In terms of *Culture* in Green BPM, what are the essential values and attitudes for meeting Green BPM objectives? What is the role of social networks in Green BPM?

7   Conclusion

This study aimed to analyze the current state of research on Green BPM. To that end, we conducted a literature review, which comprised several studies on Green Business Process Management that were categorized according to the six core elements of BPM. We found that most of the contributions were presented as conceptual studies and that the majority of papers were focused on methods and techniques that consider sustainability factors in business process management. We contributed with the description of the Green BPM lifecycle based on the methods, techniques, and approaches derived from the analysis of the literature. We argued that the Green BPM lifecycle can serve as a framework for future studies that aim to apply, combine, and compare methods that can be utilized in each phase of the business process management lifecycle to help organizations become more environmentally sustainable, thus reducing their impact on the environment. We discussed key gaps regarding Green BPM that emerged from our analysis, and suggested avenues for future research for each core element. We argued that future research should consider all six elements of BPM, and should evaluate and propose means to address the environmental impact of business processes. Furthermore, this study is not without limitations. First, we did not have access to full-text versions of all papers, so some relevant contributions might not

have been included in this study. Having access to full-text papers for all literature found could have disclosed additional Green BPM approaches. Second, the paper coding was conducted by only one person, which might have led to biased paper classification. It might have been better if two researchers had been involved working on a pair coding mode. Still, by using the criteria provided by the BPM maturity model [8] the author took care to base the coding on formal concepts derived from the literature.

Acknowledgments

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