



Sustainability in facilities management: an overview of current research

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SUSTAINABILITY IN FACILITIES MANAGEMENT: AN OVERVIEW OF CURRENT RESEARCH

1. INTRODUCTION

Climate adaptation, energy efficiency, sustainable development and green growth are societal challenges for which the facilities management profession can develop solutions and make positive contributions at the organisational level and have societal-level effects. It is well known that buildings are responsible for approximately 40% of the total energy consumption and one-third of greenhouse gas emissions in Europe (COD/2008/0223) and the U.S. (USGBC 2013). Furthermore, an estimated 80% (Junnila et al., 2003; Junnila 2004; Junnila et al., 2006) of the climate change impacts caused by buildings are created during their operating phase. The operating phase of a building is important not only for energy but also in relation to other sustainability challenges such as food consumption, biological diversity in the built environment, health, poverty and the use of non-renewable resources. Therefore, the ways we use, operate and manage buildings will have a substantial influence on the entire building sector, society and the planet in the near future. As Miller (2010) suggested, focusing on the operation and management of buildings will create relatively more rapid advances in the sustainability sphere because a building's operation can be more critical than its design in this respect.

Sustainable facilities management (SFM) has been identified as one of the emerging themes in the future of facilities management (FM) research (Andersen et al., 2012), has been selected as one of the top research themes in the EuroFM network (Junghans, 2012) and is the subject of an increasing number of research articles, presentations and discussions. As this body of knowledge is evolving, it is difficult to develop an overview of the current literature, as relevant articles have been published in many journals and under various sub-topics. From our own research on SFM (as a multidisciplinary phenomenon based in FM practices), we know from experience that SFM-relevant knowledge is published in journal articles on, e.g., buildings, sustainability or construction management and not only in FM journals such as *Facilities* or *Journal of Facilities Management*. However, scholars and academics must obtain such an overview to base their research on existing knowledge and gain an overview of the main contributors to the development of this growing body of knowledge. In the words of Webster and Watson (2002), it is most useful to analyse the past to prepare for the future, and this also applies in SFM research.

Junghans and Olsson (2014) identify FM as an academic discipline on the basis of 6 characteristics: (1) object of research; (2) body of knowledge; (3) theories and concepts; (4) technical language; (5) research methods; and (6) institutional manifestation. SFM has yet to reach the stage of maturity necessary to be identified as an academic discipline in itself, but it is a topic of growing importance within the academic discipline of FM. The object of SFM research is the integrated whole of a complex sociotechnical system at the building level, consisting of elements such as buildings and building operation, use, maintenance and management processes, and how this system can be managed to contribute to sustainable development in society. Sustainable development is measured in terms of environmental, social and economic sustainability. The aim of this literature review is to identify the accumulated specialist knowledge referring to SFM and initiate sharing of theories and concepts that can organise the accumulated specialist knowledge and research methods. Based on the identified academic literature, the ambition was to gain an overview of the following topics: what type of SFM knowledge already exists; what characterises the research design of previous approaches; and what seems to be missing. Doing so could provide guidance for future SFM research.

To the best of our knowledge, no one has collected and classified the available academic literature in the emerging sub-discipline of SFM, as Ventovuori et al. (2007) did for facilities management 7 years before Junghans and Olsson (2014) designated FM as an academic discipline. In their review and classification of the academic

literature, Ventovuori et al. (2007) analysed the topics considered, the authors' backgrounds and the methodologies used. They highlighted the need for further hypothesis testing and more explicit use of theories. A similar analysis of the current SFM literature is needed, including which topics are addressed, which theory (or theories) is applied, what constitutes empirical evidence, and what conclusions are drawn. This overview of what we know and what we need to learn will be useful to not only to those engaged in SFM as researchers or scholars but potentially also as practitioners or policy makers in the fields of climate, energy, sustainability and the built environment.

The purpose of this paper is to develop a comprehensive understanding of the current research on sustainability in facilities management and to contribute to the understanding of SFM by categorising previous research. The specific aims of this article are to:

1. Identify all relevant published journal articles from the last five years (2007-2012) that focus on *sustainability and the use, operation and management of buildings* (including commercial and residential buildings).
2. Examine the individual articles in a structured way according to their topic.
3. Interpret each article's focus and findings and present a balanced and impartial summary of the findings of 3 basic SFM questions:
 - a. How can we document and measure the performance of building operations in terms of environmental, social and economic impacts?
 - b. How do we improve the sustainability performance of buildings?
 - c. What are the potentials for and barriers to integrating sustainability into FM at the strategic, tactical and operational levels?
4. Identify gaps in the literature and, especially, investigate whether there is a gap in multi- and trans-disciplinary research using an integrated strategic approach to SFM, as our assumption is that this type of research is of particular value for practitioners, who require competencies for integrating sustainability into FM at the strategic, tactical and operational levels.

The original research contribution of this article is to provide a systematic literature review and an analysis and synthesised descriptions of the identified literature. Thereby, the paper contributes to the definition of SFM and provides a classification of articles, which are particularly useful for academics searching for a reliable starting point for their own endeavours in sustainable facilities management. Therefore, the literature analysis is as transparent as possible, and in addition to the data analysis tables presented in the article, tables listing the statistics of scanned journals and articles are provided as appendixes.

The remainder of the article is organised as follows. The next section presents the data collection and analysis methodology, namely a systematic literature review. We then discuss the analytical process and present the results of the review. The conclusions and contributions of the study are discussed in the final section.

2. A SEARCH FOR LITERATURE – THE SYSTEMATIC LITERATURE REVIEW

As the purpose of this study was to develop a comprehensive understanding of the research related to sustainable facilities management, basic keyword-based data scanning was insufficient. According to Fink's (2005) definition, a rigorous stand-alone literature review must be *systematic* by following a methodological approach, *explicit* in explaining the procedures by which it is conducted, *comprehensive* in its scope by including all relevant material, and therefore *reproducible* by others who would follow the same approach in reviewing the topic. Therefore, a systematic literature review, or rather, a *mixed-method systematic review*, was chosen as a proper data analysis method for the purpose of this article. (Systematic reviews may examine quantitative or qualitative evidence, but when two or more types of evidence are examined within one review, it is called a *mixed-method systematic review*.)

Based on Okoli et al.'s (2010) "eight steps for systematic review", the following guidelines were formulated to instruct and guide the researchers during the process. The written guidelines may also help other researchers to follow the steps of this literature review and understand the decisions made along the way.

1. *Purpose of the literature review*: The first step in the review was to identify the purpose and intended

goals of the review. The purpose and goals were discussed and agreed upon amongst the three researchers and are stated in the introduction section of this article. The purpose was to identify current research on the sustainability aspects of buildings in their operation phase, with the goal of identifying a common body of knowledge currently supporting the practice of strategic sustainable facilities management (also termed strategic facility management, sustainable strategic property management or sustainable strategic real estate management). As the societal challenge concerning sustainability is primarily the result of an environmental crisis, we decided to also include literature concerning environmental management.

2. *Protocol and training*: The review employed three researchers; hence it was critical that the researchers shared a mutual understanding of the purpose and scope of and criteria for the review and article scanning. To ensure consistency, detailed procedures for data collection, scanning and analysis were written down and followed throughout the process.
3. *Journal selection*: Journal articles are the primary vehicles for communication in most scientific disciplines, and therefore, published journal articles were chosen as the primary data source for this review. All peer-reviewed, scientific journals within 34 databases (the database names are listed in appendix 1) were chosen using the following keywords: facilities, facility, real estate, property, construction, building, built environment, sustainability, sustainable, responsibility, and environmental management. In total, 85 journals and 19 068 articles published during the last five years (2007-5/2012) were included in the review. A list of the journals can be found in appendix 2.

Other key words could have been added, e.g., Corporate Social Responsibility (CSR); **economy, sociology, energy**, but the research had to be limited. However, new key words should be added as a discipline emerges, as there seem to be changes in the terms and expressions used to denote very similar objects.

Incorporating conference articles and books into the review was discussed, but we decided to exclude them from the review. This decision was chiefly due to the widely varying practices of delivering conference articles, their limited availability and the lack of criteria for determining the “scientific level” of the published books.

4. *First screening round*: By screening the titles and keywords of the 19 068 articles, 1078 (5%) articles were chosen that focused on the management/operations/use phase of buildings and at least one of the sustainability aspects (environmental, economic, social).
5. *Second screening round*: Based on the abstracts of the 1 078 articles selected in the first screening round, 166 (15%) articles were selected for further analysis. During the second screening round, articles that did not study the object of *sustainability/environmental sustainability and the use, operation or management* of buildings were excluded. Following this screening, we ultimately had 151 articles (14%), which are listed in appendix 3.
6. *Data extraction and analysis*: Once all of the articles for the review had been identified, the reviewers needed to systemically extract the applicable information from each study and combine the facts across the articles using appropriate techniques. We chose to focus on the content of the studies, grouping and counting the number of articles according to general research topics, which implies the use of both quantitative and qualitative techniques to analyse the articles. We performed this analysis by forming a joint “article analysis framework” that guided us in analysing the abstracts of the articles. The main columns were as follows:

- **Focus of the article (Building/Process/Management)**:
The extent to which the article intended to focus on knowledge production: only about the building, only processes during operation and use, management aspects, or several in combination.
- **Aspects of sustainability (Environmental/Social/Economical)**:

Sustainability is defined according to the three dimensions of Brundtland's definition: environmental, social, and economic. Some articles address one dimension; others address two or all three.

- **Property type (office/housing/retail/other):**
The context of SFM is acknowledged to be important and varies according to use, ownership and other factors. Therefore, solutions and best practices might vary among different types of properties and are relevant to the specific property context.
- **Methodology (quantitative/ qualitative/ survey/ interviews/case studies/etc.):**
The research methodology is relevant to identifying what type of knowledge is produced and what could still be missing.
- **Data sample:**
Articles are based on variable data samples. What was their specific focus?
- **Applied Theories:**
Because the FM discipline, and especially SFM, is emerging, it is important to identify the related areas of theory to understand the current basis and identify any gaps.
- **Key findings:**
What have researchers in SFM found thus far?

The data analysis resembled a grounded theory approach, whereby a set of rigorous research procedures leads to the emergence of conceptual categories. These dimensions or categories are related to one another as a theoretical explanation of the action(s) that continually resolve the main concern in a substantive area. Dimensions that do not “work” or “fit” the data are excluded during the data analysis process, and newly discovered dimensions are added. The openness of the researcher to new dimensions outside the predetermined categories is fundamental to the process. In our case, we identified 8 areas of concern based on the articles' purpose and practical implications and included a ninth classification: “out of category”. The researchers agreed that these categories were meaningful, after a period in which they individually screened approximately 1/3 of the literature. **Microsoft EXCEL was the only software applied. In future studies, the use of analytical software such as NVivo is recommended.**

The systematic literature review was conducted over a 12-month period. During the research period, new publications were released, and they are not included in this study due to limited time and available resources. However, studying the articles released during the 5-year period considered here provided a unique overview of current SFM research, as well as a basis for further research and the formulation of research programs in sustainable facilities management.

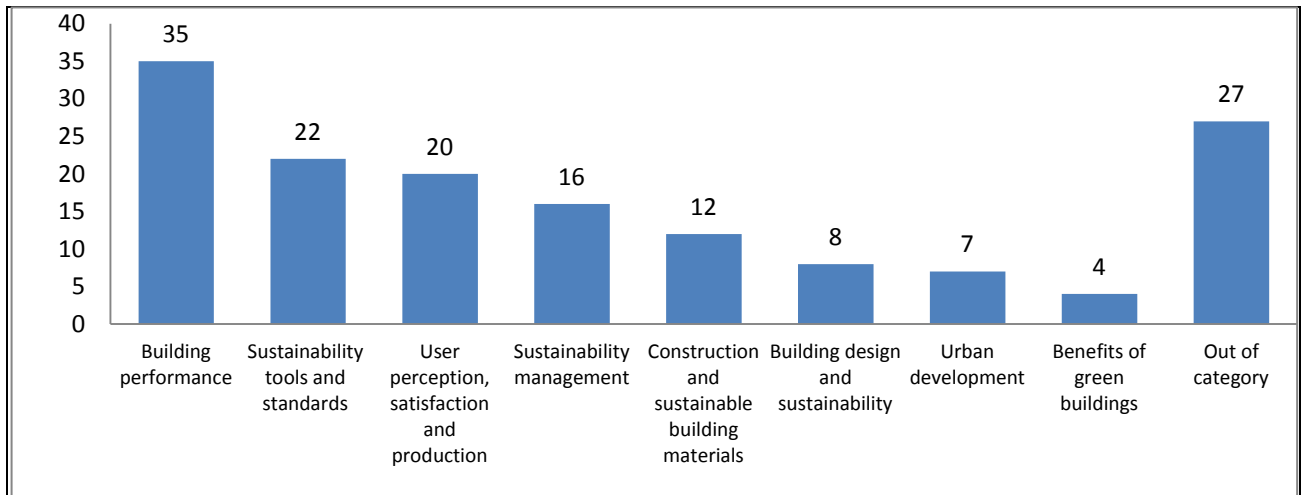
3. ANALYSIS OF CURRENT SFM RESEARCH

Based on an analysis of their abstracts, the 151 articles were divided into the following 9 categories:

1. Construction and sustainable building materials
2. Sustainability tools and standards (indicators, certifications, management systems, etc.)
3. Building performance (e.g., LCA, CO₂-emissions)
4. Urban development
5. Building design and sustainability (design and design concepts)
6. Sustainability management in the built environment (strategy and management)
7. Benefits of green buildings
8. User perception, satisfaction and productivity
9. Out of category (other)

Table 1 provides the statistical data for the number of articles within each category. Because an individual article should only be counted once in our quantitative analysis, we assigned each article to the category to which it primarily belongs. In the following section, we synthesise each category of articles and present the analysis.

Table 1. Current research on Sustainability in Facilities Management: Data on the number of articles assigned to each of the 9 categories for 151 articles in total.



3.2. QUALITATIVE ANALYSIS

In the following sections, we synthesise each category of articles and present the findings, starting with the largest category by number and finishing with the “out of category” group.

3.2.1. BUILDING PERFORMANCE

This is largest group of articles, with 35 of the total 151. Most studies focus on measuring and improving the energy performance of buildings and use energy consumption and CO₂ emissions as performance measures. These studies are mainly quantitative and technical, presenting Life Cycle Assessments (LCAs) and developing simulations and case studies concerning energy performance, with a few studies (e.g., Ucar et al., 2010) also including other emissions. A few studies focus on the relationships among health (e.g., Zang et al., 2009 and Hanie, 2010), the environment and economic effects. From the perspective of property type, commercial buildings dominate, but museums, residential buildings and educational buildings are also studied. The theoretical basis of these studies is generally building physics. Research suggests that it is necessary to use scenarios to inform contemporary decision making to avoid overheating problems in the future (Ngarmpornprasert et al., 2009). Additionally, the execution of carbon audits should be eased (Lai et al., 2012), and environmental control is a crucial capability in which organisations should invest (O’Neill, 2010).

3.2.2. SUSTAINABILITY TOOLS AND STANDARDS

These 22 studies focus on the analysis of sustainability tools, green building indicators and certifications, especially developing tools and measurement systems or analysing tool performance (e.g., Kientzel et al., 2011 and Kajikawa et al., 2011). The studies primarily discuss sustainability at the building level and use indicators from the environmental perspective, but a few specifically address environmental, social and economic perspectives of sustainability (e.g., Xu et al., 2012, Hiete et al., 2011 and Mathur et al., 2008). With respect to property type, “green buildings” and “conventional buildings” are studied, and most are office buildings. Only a few studies concern housing (e.g., Malmqvist et al., 2009), hotels (Xu et al., 2012) or universities (El-Dash, 2011). The studies are typically surveys or case studies. This research is typically deductive in nature, and no relevant basic theories are explicitly applied. The research results suggest that one should be careful when utilising KPIs. One should also establish integrated design teams and apply new concepts such as green leases.

3.2.3. USER PERCEPTION, SATISFACTION AND PRODUCTIVITY

The articles within the “user perception, satisfaction and productivity” category (20) typically focus on the results of employee satisfaction surveys and post-occupancy evaluations of green buildings (e.g., Armitage et al., 2011 and Khalil et al., 2009). These studies seek to determine user perceptions of/satisfaction with environmentally sustainable buildings. The focus is typically on building, process and management as an integrated whole, with environmental and social perspectives predominating. The methodological approaches are primarily surveys and literature reviews, but this category also includes experimental activities (Wilde et al., 2010), business process modelling (Atkin, 2007), walk-through investigations, focus group meetings, interviews and public hearings (Hassanain et al., 2010). Applied theories are only vaguely described and seem to come from

the built environment, but a few studies also mention theories from the productivity management and business areas. Typical results indicate that tenants are more satisfied with or productive in a green building than a non-green building (e.g., Smith et al., 2011) and that tenants are more willing to occupy green buildings than non-green buildings.

3.2.4. SUSTAINABILITY MANAGEMENT IN THE BUILT ENVIRONMENT

These articles (16) all address building and management issues in a broader sense and at a more strategic level compared with the “sustainability tools and standards” category. A focus on environmental aspects predominates, and a few articles specifically address the need to adapt to climate change and extreme weather events (Warren, 2010, Warren, 2010a and Carthey et al., 2009). These articles generally address the need for stakeholders such as building owners, landlords, residents and others to be motivated and somehow involved in establishing new practices. Half of the studies do not specify the property category, and the other half address varied property types (housing, public buildings, retail establishments or world heritage sites). The most commonly used methodology is case studies of best practices and surveys, but there are also interviews and focus group studies. The studies generally recommend strategies for good practices and value demonstration (e.g., Tam et al., 2007 and Chrusciel, 2011). Some studies specifically identify ways of improving strategic energy management (Smid et al., 2008), ways to reduce energy consumption within retail locations (Thompson, 2007), the need for disaster planning (Warren, 2010a) and challenges in public participation and world heritage city maintenance (Yung et al., 2012). Elmualim et al. (2010) study the barriers facing the facilities management profession and its commitment to the sustainability agenda; those authors find that the main barrier is a lack of commitment by senior executives.

3.2.5. CONSTRUCTION AND SUSTAINABLE BUILDING MATERIALS

These studies (12) primarily focus on individual materials but also consider building products and elements, e.g., facades, with the purpose of documenting the effect of new construction and building materials. Most studies investigate how a new construction design or building material supports energy efficiency or carbon footprint reduction. The aim of this research is to support the choice of materials and demonstrate the impact of energy efficiency. LCAs are also the dominant framework here (as an assessment/evaluation method), in combination with case studies. The property type varies. This research suggests that building materials should be local, renewable resources and that the extraction of the materials should be source-efficient (Esin et al., 2008). This research also shows that the lifetime of the materials used significantly impacts the LCA and maintains that the goal should be long building lifespans (Shi et al., 2009). In addition, the lifetimes of windows, walls and wall materials affect green marked schemes and buildable design appraisal systems (Sighaputtangkul et al., 2011).

3.2.6. BUILDING DESIGN AND SUSTAINABILITY

Eight of the 151 (5%) articles discuss sustainable design and its influence on the operating phase of the building. These articles are primarily published in building or construction journals. The focus is logically on buildings or design. It is typical for these articles to focus not on a specific property type but on concepts. The studies represent a combination of qualitative, theoretical and conceptual studies; however, their methodologies are more varied than those of the other categories and include net present value calculations (Saari et al., 2008), BIM modelling (Nguyen et al., 2010), case studies and semi-structured interviews (Renukappa et al., 2012). From a sustainability perspective, environmental issues dominate, but some studies explore economics, and one takes ethics into account (Farmer et al., 2010). Several studies highlight the need for new frameworks and improved tools for integrating sustainability within building design and the construction industry. Farmer et al. (2010) argue that the environmental ethics of sustainability are absent from the professional debate on sustainable architecture and call for an analytical and moral framework that links the environmental ethics of sustainability to the design, construction and use of buildings. They reference the philosophy of pragmatism to encourage a deeper engagement with sustainable architectural practice and explore broader sociological or philosophical questions beyond narrow “how to” debates.

3.2.7. URBAN DEVELOPMENT

Seven studies focus on urban development, but less from a traditional property management perspective, as they address cities’ needs for sustainable community development, affordable housing, attractive parks, climate adaptation, risk management (natural catastrophes) and integrating sustainability aspects into sector development (energy, utility, transport, construction). Compared with the studies in the other categories, these studies feature a more dominant social dimension related to environmental achievements. In these studies, the economic focus is less explicit. There is generally no specification of the applied theories within this category. The article by Alves et al. (2008) is representative of the articles in the “user perceptions” category because it reports older people’s preferences for urban parks and finds that older people prefer a neighbourhood park that does not have nuisances

but does have cafes and restrooms, many trees and plants, light traffic, wildlife to watch and regular maintenance. However, these preferences were affected by the older people's functional capabilities.

3.2.8. BENEFITS OF GREEN BUILDINGS

Four studies explore building owners' motivation for developing a sustainability strategy for their properties, and this constitutes the smallest category by number. The focus varies from the building (Beach, 2011) to the building and its users (Kwane et al., 2009), a green building as workplace with a cultural context (Brown et al., 2010), and the general risks and benefits of going green within existing buildings (Durmus-pedini et al., 2010), including for the building, its processes and management. The environmental perspective dominates, but three of the four articles combine this perspective with either an economic or social perspective. The property types vary from retail to offices, a headquarters and general buildings. Variation among the articles can also be observed in their methodology and data sources. One study bases its case study on financial reports, another study reports a survey of commercial real estate users, a third article is purely a literature study, and the fourth is a combination of a literature study and a case study.

A survey of 400 commercial real estate users in Singapore (Kwane et al., 2009) reveals that respondents are aware of and appreciate the benefits of green buildings. However, they are not willing to occupy and/or invest in green buildings because they are concerned with monetary returns. The price, reliability and effectiveness of green features are important. Cost savings in combination with higher property values are highlighted as realistic economic arguments in favour of green buildings, and at least for some firms, an increase in sustainability funding can result in an increase in firm value.

A case study of a company's move to a new green headquarters (Brown et al., 2010) concludes that, while there are potentially significant gains to be made from integrating green building with workplace design strategies from the outset, there are many other factors beyond the quality of the space that may play a role in shaping user experiences. Links are made to organisational and workplace research and the post-occupancy evaluation of buildings.

Studies such as that by Durmus-pedini et al. (2010), in an overview of the risks and benefits of going green in existing buildings, argue that decision makers should develop a risk management strategy and a plan to limit eventual damages.

3.2.9. OUT OF CATEGORY

Category 0, "out of category", is used for articles that do not fit within the chosen categories and for articles that are so broad in their focus that they are unique rather than related to articles on the same topic. The category "maintenance" was considered because it is the topic of several articles (e.g., Straub, 2011, Lewis et al., 2011, Abdu et al., 2011, Idrus et al., 2009). However, we decided that this topic did not warrant a separate category, as it was covered within only a few journals and was integrated with other topics.

None of the studies focus solely on the building; they all focus on either management or the broader perspective of building/processes/management. Half of the studies do not specify the researchers' understanding of sustainability in the abstract, and the other half of the studies generally adopt an environmental perspective. The property types vary from hotels to sports complexes, multifamily houses, universities and office buildings. Other studies do not specify the property type because their focus is broader, such as the national construction sector (Bröchener, 2010 and Love et al., 2011), the FM profession (Adewunmi et al. 2012, Kyrö et al., 2012, Staub et al., 2011), or generic terms and management tools (e.g., Nielsen et al. 2012; Gheisari et al. 2011, Love 2011). With respect to methodology, the studies in this category are primarily literature reviews and surveys, but one article also includes workshops and a case study. A few studies mention their theoretical basis, including a philosophy of science informed by action research (Lewis 2011), knowledge management (Baharum et al., 2009) and service innovation (Bröchner, 2010).

Very relevant questions are addressed in this category, such as the extent to which managers and facilities managers have sustainability on their agendas. The answer to this question for hotels in Macao is not at all (Penny, 2007). Another study (Kyrö et al., 2012) confirms that, in theory, facilities managers are key to reducing greenhouse gases, but in practice, this is not the case. Price et al. (2011) show that the larger organisations are, the more likely they are to have explicit SFM practices. Only one article (Ventovuori et al., 2007) focuses on

academic research and concludes that FM academic research needs to be much more aware of its methodology if it is to advance.

4. DISCUSSION

In this section, we discuss our findings and comment on the status of current research, as well as suggest directions for future research.

The study was intended to identify and examine recent journal articles on the management of buildings during their operational phase and identify the literature informing FM that emphasises sustainability. In total, 85 journals were identified as relevant, and we identified nearly 20 000 articles, of which only 151 emphasise sustainability.

What we identified as sustainable facilities management literature applies to a very diverse body of articles that vary in focus, research methodology, theoretical application and empirical data. However, in our view, the 9 categories cover all relevant research questions that should inform the FM profession, including researchers. We believe that relevant questions must be answered, such as the following:

- How can we document and measure the performance of building operations in terms of environmental, social and economic impacts? The literature offers some suggestions for how that could be achieved through LCA analysis, environmental management systems and other functions. (See sections 3.2.1 and 3.2.2.)
- How do we improve the sustainability performance of buildings? The literature states that improvements can be made by adding new building materials, designing buildings with new concepts, using new management tools and engaging with building operators and users. (See sections 3.2.3; 3.2.5 and 3.2.6.)
- What are the potentials for and barriers to integrating sustainability into FM at the strategic, tactical and operational levels? There are current studies that provide relevant answers not only regarding the sector in general but also specifically in relation to commercial buildings, hotels, universities and public buildings. (See sections 3.2.4; 3.2.7 and 3.2.8.)

Our general impression is that the current SFM literature remains limited and scattered, especially if a more restrictive approach is adopted and sustainable facilities management is defined only according to a strategic perspective on the building, processes (operation and use) and management practice as an integrated whole. From our perspective, all three areas are necessary for sustainable strategic facilities management. Adopting this definition would exclude the studies that focus solely on the physical building.

Another observation regards the aspects of sustainability that, according to the Brundtland definition, have environmental, social and economic dimensions. Most articles only focus on the environmental aspects of sustainability, and very few focus only on social sustainability. This finding may be because of the limited scope of the literature review, as we did not deliberately search for literature in, e.g., economic or sociological journals. However, from our perspective, all three dimensions should be emphasised in FM, although doing so would increase the complexity of FM as a management discipline and, in our experience, exacerbate the dilemmas and ethical issues that also could be considered.

Case studies of certain property types are common in the literature; however, the property type varies from offices to housing, retail locations, hotels, universities, world heritage sites and others. Acknowledging that the strategic facilities management organisation (SFMO in Nielsen et al., 2012) differs according to ownership, the specific roles of and relationships among users, administrators and facilities managers, it is important to study the same research questions for other property types. The technical building component is likely to be the same, but its use and strategic and economic contexts will be different. From our perspective, researchers should seek to explicate not only generic aspects of SFM but also the specific context.

A literature review by Ventovuori (2007) concludes that FM research should become more explicit about its research methodology and the use of theory. In our study, we found that a variety of research methodologies are used, especially surveys, case studies, action research and theoretical experiments (simulations). From our perspective, we welcome the diversity of research approaches because they produce different types of knowledge, and similar to Saunders et al. (2006), we assert that no research methodology is better than another. Issues of

quality rely more on the research question, available empirical data, a deliberate and reflective research approach, and validation of findings. In general, the identified studies are nearly all cross-sectional analyses, and very few are longitudinal. Therefore, we conclude that longitudinal studies represent a gap in the current research and could provide information on the long-term effects of certain SFM strategies and interventions.

We examined the use of theory and found that approximately 2/3 of the articles in the current literature do not explain any theoretical issues (either the theory applied or the theoretical body to which the researchers contribute). In the building-focused articles, we identified theories that implicitly include management science, building physics, natural science and environmental management. Other theoretical fields include management theory, knowledge management, action research, service innovation, asset management, value engineering and philosophy of science. In future research, we recommend a much more reflective approach to the theoretical component of research projects because such reflection would clarify the research ambitions and the research approach, as well as establish an explicit theoretical connection to other bodies of research.

A final reflection on our observations concerns the need for relevant practical research and the applied philosophy of science. Journals have different profiles and different focus areas, which means that the framing of sustainability in relation to facilities management ranges from a narrow understanding of CO₂ emissions to a broad concept of a complex socio-technical system in transition. In natural science journals, research methods are based on positivistic assumptions, and the knowledge created therein is connected to physical tests, such as building performance and is thus 'valid' in the sense it has been 'proven'. In social and management sciences, the knowledge created is based on a social constructivist basis, but even here, positivistic methods such as statistical tests are applied (in a tenant survey). In our examination, we found that, epistemologically, FM is approached in many ways, making it difficult to bridge knowledge and thus create a coherent body of FM knowledge. As a result, we hold that an SFM literature exists, and 151 key articles of current SFM research were identified, but because of the diversity, we concluded that the current research is relatively scattered and only weakly connected. Although FM is recognised as a multi-disciplinary research and practice field, it is not addressed in the research literature. In practice, however, knowledge must be bridged, as the facilities manager must understand the technical disciplines, the life worlds of the users and managerial challenges connected to the field. As a logical conclusion, we highlight the need for more multidisciplinary and trans-disciplinary research to support the emerging discipline of SFM.

The aim of this study was to provide an overview of published journal articles in the broad field of sustainable facilities management. For practical reasons, we limited ourselves to articles published in the period 2007-2012, although relevant studies had been published before and were published during the production of this article, or in communication channels other than academic journals. Therefore, the search for current articles regarding sustainable facilities management must be viewed as an on-going quest, rather than a guarantee, and overviews of databases (appendix 1), journals (appendix 2) and selected articles (appendix 3) are included, such that others may continue this identification and examination of studies in the SFM literature.

CONCLUSIONS AND FUTURE WORK

This literature review set out to identify all relevant published journal articles from the last five years (2007-2012,) focusing on both *sustainability and the use, operation and management of buildings* (including commercial and residential buildings), to examine and synthesise the individual articles in a structured way, and to identify gaps in the literature. We identified 85 journals and 19 068 articles were identified out of which and examined 151 articles that together represent a broad basis of essential readings that form a scientific knowledge basis for current practices and for positioning future research in SFM. The appendixes include lists of databases, journals and articles as a shared resource for future literature reviews.

The largest group of articles, representing 35 of the total 151, focuses focus on measuring and improving the energy performance of buildings using energy consumption and CO₂ emissions as performance measures. Furthermore, 22 studies focus on analysing the implementation of sustainability tools, green building indicators and certifications, with a particular focus on developing tools and measurement systems or analysing tool performance. The 20 articles within the "user perception, satisfaction and productivity" category typically focus on the results of employee satisfaction surveys and post-occupancy evaluations of green buildings. The 16 articles categorised as "sustainability management in the built environment" all address building and management issues in a broader sense and at a more strategic level compared with the "sustainability tools and standards" category.

Next, 12 studies focus primarily on individual materials but also address building products and elements, e.g., facades, with the purpose of documenting the effect of new construction and building materials. Eight of the 151 articles discuss sustainable design and its influence on the operating phase of the building. Seven studies focus on urban development, but less from a traditional property management perspective, as they address cities' needs for sustainable community development, affordable housing, attractive parks, climate adaptation, risk management (natural catastrophes) and integrating sustainability aspects into sector development (energy, utility, transport, construction). Only 4 studies explore building owners' motivation for developing a sustainability strategy for their properties, and these constitute the smallest category by number. The last 27 articles was categorised as "out of category"; as they deviated from the 8 categories we developed.

The current research addresses important questions for the emerging discipline of sustainable facilities management; our conclusion is that current SFM research is limited and scattered. The body of empirical data is often quite small (e.g., data from only one country or even only one case study), or the methodological approach produces only one type of knowledge (e.g., surveys providing insights into current user satisfaction levels). Other research methodologies could provide supplementary information to more fully respond to the challenges in FM. A general deficit in the current literature is the absence of longitudinal studies in which the long-term effects of interventions are thoroughly investigated.

From this literature review, we conclude that SFM research-based knowledge remains a niche within the FM research literature and that there is a need for considerably more research to gain a deeper understanding of sustainability in FM and of the dynamic socio-technical complexities of operating and managing buildings in use. Future SFM research should be directed towards understanding and developing the following: (1) visions, strategies and capabilities that enable FM professionals to operate with a holistic mind-set and a clear sustainability perspective. (2) Sustainable technologies that can enable a sustainable transition at the organisational, building and societal levels. This implies that any new tool or practice should be viewed in the context of its use and operation to avoid overestimating its positive or negative effects. (3) Sustainable facilities management in practice is not a simple matter but includes complex challenges with numerous dilemmas, such as how to prioritise energy savings in comparison with quality, economy and health. This is a part of the everyday life of SFM professionals. Research should support the development of codified knowledge for the education of FM professionals and should include competencies for integrating sustainability into FM at the strategic, tactical and operational levels to plan and communicate with users and other internal/external stakeholders.

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APPENDIX 1: LIST OF DATABASES USED

ABI/INFORM (Proquest)
Academic Search Elite (EBSCO)
ACS Publications
AES Electronic library
Annual Rev:Physical sciences
Annual Rev: Social Sciences
Annual Reviews All series
Art & Humanities Full Texts (Proquest)
Bentham Direct –Test use
Business source complete (EBSCO)
CE database (ASCE)
CEPR Discussion papers
CogPrints via SCIRUS
DOAJ Directory of Open Access Journals
Education Journals (ProQuest)
Emerald Journals (Proquest)
IEEE/IEE Electronic Library
IngentaConnect
InTech –Open Access Publisher
JSTOR
JSTOR- Arts & Science Collection
JSTOR-Business Collection
Nature (NPG)
OECD iLibrary
PLoS Journal
Primo Central Index (Ex Libris)
SAGE Premier
Science
Science Direct (Elsevier)
Scitation
SPIE Digital Library
Springer Link
Taylor & Francis Online
Wiley Online Library

APPENDIX 2: ALPHABETICAL LIST OF 85 SCIENTIFIC JOURNALS

Advances in building energy research
Advances in Environmental Accounting and Management
Building and environment
Building research and information
Building services engineering research & technology
Building simulation
Built Environment Project and Asset Management
Construction & building materials
Construction innovation
Construction Management and Economics
Corporate social-responsibility and environmental management
Current Opinion in Environmental Sustainability
Energy and buildings
Energy for Sustainable Development
Engineering construction and architectural management
Environment, development and sustainability
Environmental management
Environmental progress & sustainable energy
Environmental quality management
Facilities
Housing studies
Housing, theory and society
Indoor and built environment
Integrated environmental assessment and management
International journal of disaster resilience in the built environment
International journal of environment and sustainable development
International journal of facility management
International journal of housing markets and analysis
International Journal of Housing Policy
International journal of innovation and sustainable development
International Journal of Law in the Built Environment
International journal of strategic property management
International journal of sustainable energy
International journal of technology management & sustainable development
International Real Estate Review
Journal of applied science & environmental management
Journal of Asian Architecture and Building Engineering
Journal of building appraisal
Journal of building physics
Journal of construction engineering and management
Journal of corporate real estate
Journal of environmental assessment policy and management

Journal of environmental economics and management
Journal of environmental management
Journal of Environmental Planning and Management
Journal of Environmental Science for Sustainable Society
Journal of European real estate research
Journal of facilities management
Journal of financial management of property and construction
Journal of financial management of property and construction
Journal of Housing and the Built Environment
Journal of Housing and the Built Environment
Journal of housing economics
Journal of Housing Research
Journal of Management & Sustainability
Journal of performance of constructed facilities
Journal of property investment and finance
Journal of property research
Journal of real estate finance and economics
Journal of real estate literature
Journal of Real Estate Portfolio Management
Journal of real estate practice and education
Journal of renewable and sustainable energy
Journal of retail & leisure property
Journal of Strategic Innovation and Sustainability
Journal of sustainability science and management
Journal of sustainable development
Journal of Sustainable Energy
Journal of sustainable real estate
Journal of sustainable tourism
Management of environmental quality
Property management
Real Estate Economics
Seniors housing & care journal
Social responsibility journal
Sustainability
Sustainability Accounting, Management and Policy Journal
Sustainability Science
Sustainable Cities and Society
Sustainable Construction & Design
Sustainable development
Sustainable development law & policy
The journal for education in the built environment
The Journal of real estate research
The Open Construction & Building Technology Journal

APPENDIX 3: LIST OF ARTICLES

CATAGORY 0: OUT OF CATAGORY

1. Abdul Lateef, O. A., Khamidi, M. F., & Idrus, A. (2011). Appraisal of the building maintenance management practices of Malaysian universities. *Journal of Building Appraisal*, 6(3-4), 261–275.
2. Adewunmi, Y., Omirin, M., & Koleoso, H. (2012). Developing a sustainable approach to corporate FM in Nigeria. *Facilities*, 30(9/10), 350–373.
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15. Love, P., Edwards, D., Love, J., & Irani, Z. (2011). Champions of practice: context and habitus for unbounded learning in construction projects. *Facilities*, 29(5/6), 193–208.
16. Marini, E., Zawawi, A., & Kamaruzzaman, S. N. (2009). Personnel Characteristics of Maintenance Practice : A Case of High-Rise Office Buildings in Malaysia. *Journal of Sustainable Development*, 2(1), 111–116
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18. Nielsen, S. B., Jensen, P. A., & Jensen, J. O. (2012). The strategic facilities management organisation in housing: Implications for sustainable facilities management. *International Journal of Facility Management*, 3(1), 1–15.
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CATAGORY 1: CONSTRUCTION AND SUSTAINABLE BUILDING MATERIALS

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CATAGORY 2: SUSTAINABILITY TOOLS AND STANDARDS

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