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Environmental Management Information Systems (EMIS) Revisited: Towards a Research Agenda for Energy

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6P. Environmental Management Information Systems (EMIS) Revisited: Towards a Research Agenda for Energy

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Abstract

Environmental issues are nowadays a challenging topic in several research disciplines. Scare resources, environmental pollution, and the rising awareness for resource-friendly behavior guides companies to emphasize environmental aspects in their business decisions and reporting. To achieve this, Information Technology (IT) plays a vital role as an enabler for sophisticated reporting and analytics. In general, these IT systems are called Environmental Management Information Systems (EMIS). This papers aims to provide an overview of the current research status on EMIS globally in information systems research. This is done by conducting a structured literature study in relevant research outlets. Based on this result, a research agenda is outlined to reflect the current development in environmental topics like energy provisioning in IS research. This research agenda identifies relevant research directions for academia as well as synergetic potential in industry practice for further development.

Keywords

Energy Analytics, EMIS, Literature Study

1. Introduction

At the latest with Meadows et al. and the Club of Rome (Meadows, 1972), the signal of the finiteness of resources has been sent. Resource scarcity is, and remains, a current and urgent issue. Resources are not only raw materials, but more specifically water and air. The careful use of resources, and thus also with the environment, is essential for the preservation of society. Environment Management Information Systems (EMIS) contribute to preserve the environment by reporting where environmental impacts like Co2 emissions and waste water are produced. Since environmental reporting becomes a duty for companies, the importance of EMIS is also growing in industrial practice. Actually, there is no established definition for EMIS. One widely accepted definition of EMIS is that EMIS is an organizational-technological system for a systematic collection, production and reporting of environmental information within a company. Is serves to collect the companys' environmental impact und support processes for the reduction of environmental impact (Haasis, 1995).

Growing awareness of environmental issues in the community and the rising possibilities for measuring environmental aspects through technological success leads to the opinion that there should be a huge discussion in the Information Systems research community on these issues. Especially in the German research community, a large number of scientific publications are

dealing with EMIS. They were first mentioned in 1989 (Lorenz M. Hilty, 1997) and are still a current research field with yearly conferences. In the international literature, the first conference for EMIS was held in 1996 in Philadelphia. (Lorenz M. Hilty, 1997) This paper addresses the question of the current scientific discussion of EMIS in a global perspective.

This paper aims to give an overview about the current research status on EMIS in the international literature. Therefore, relevant research outlets were investigated and, based on the search results, a research agenda is established. The review shows the current situation in EMIS and gives research directions for further development to protect the environment.

The paper structure is as follows: In section 2, the research area is described. The relevant key words for the search are discussed as well as the relevant publication outlets. In section 3, the key word search is analyzed quantitative and some insights about the distribution of the search result in relevant dimensions are displayed. In section 4, the results of the quantitative analysis are described. The quantitative results are segmented into a findings cluster to identify common properties. Based on this quantitative analysis, a research agenda is outlined for continuing the work in this research area. The paper closes with a summary and an outlook in section 5.

2. Research area

The aim of this study is to achieve an insight in the current research status of EMIS in Information Systems research. To achieve this, IS-relevant publication outlets were investigated. The investigation was made by searching these outlets by keyword search for relevant publications.

As a main keyword the topic itself - Environmental Management Information Systems - was taken. Pre-testing the keyword search has shown that taking established synonyms into account does not lead to a higher count of identified publications.

The keyword search was performed in three major academic publication outlets. First, the search engine of EBSCOHOST was chosen. This search engine gives access to two relevant publication databases for Information Systems research: Business Source Premier and EconLit. Second, IEEE Explore was chosen due to its major role as a publication index for academic conferences in the area of Information Systems research. Third, AISLibrary was chosen to include all major Information Systems Conferences and publication outlets globally.

2.1 Keyword Search in EBSCOHOST

EBSCOHOST provides a proprietary search mask to define keywords, their logical connection, and search limitations. As a search phrase we defined (environmental) AND (management) AND (information systems). The search was limited to academic journals. As thesaurus terms we defined information technology, management information systems, decision support systems, and computer software. The last limitation was drawn on the subject. As subjects, we defined geographic information systems, environmental monitoring, software, and sustainable development reporting.

The keyword search with these limitations has led to 271 results. These 271 results were manually scanned in title and abstract by two researches independently. This manual scan should eliminate publication results that are not valid for the research field. After this first round of investigation, 47 of the 271 publication results remain as valid for further investigation.

2.2 Keyword Search in IEEE Explore

Keyword search in IEE Explore can be conducted similarly to the search in EBSOCHOST. A proprietary search mask is used to define the search phrase. Also here, we used (environmental) AND (management) AND (information systems) as the search phrase. In contrast to EBSCOHOST, the limitations for the keyword search cannot be made as specific as needed. The refinement was made to consider conference publications and Journals & Magazines as publication outlets. Further refinements are not possible.

The keyword search with these limitations has led to 5.490 results. Due to limited resources, this large number of results could not be analyzed in detail. A first look at the results has shown that the majority of publication results are not aligned with the investigated research area. Following this, it would be suitable to adjust the search phrase, which is not possible due to the restrictions of the search mask. This leaves to manual inspection as a last option, which will be part of the future work.

2.3 Keyword search in AIS Library

Keyword search in the AIS library follows the structure of the other searches in EBSCOHOST and IEE Explore. The defined search phrase was again (environmental) AND (management) AND (information systems). However, there is no possibility to define limitations of the research despite the publication time and the publication language.

The keyword search in the AIS library has led to 381 results. These 381 results again were manually inspected in title and abstract by two researches independently, whether they are suitable for the topic or not. Furthermore, the results have been compares to the results that already exist from the former keyword search. After this manual investigation, four papers remain for extending the existing search result. 3. Quantitative Analysis

In summary, 51 papers have been identified as current body of knowledge in IS-related publication outlets. By looking at the publication date, there is a strong period between 1997 and 2011 where EMIS gained much attention (see Figure 1). Before 1997, the topic was only rarely discussed.
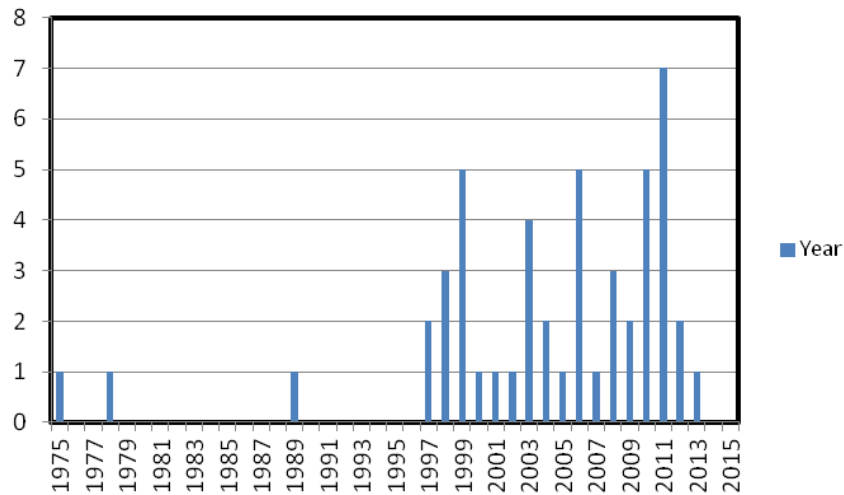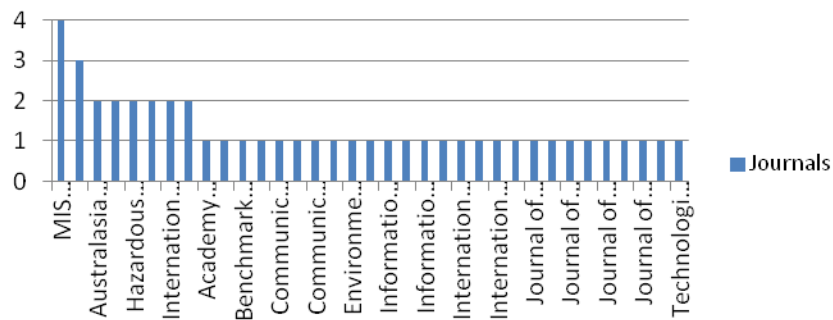
Figure 1: Overview Publication Years

In contrast to the growing interest of environmental issues in other scientific disciplines and in general, the attention in IS research is decreasing. From the current point of view, there is no clear reason for this mismatch.

Looking at the outlet distribution, there are only eight journal outlets that have more than one publication to EMIS: MIS Quarterly, Environmental Quality Management, Australasian Journal of Information Systems, Chemical Engineering, Hazardous Waste Consultant, Information & Management, International Journal of Production Economics, and Journal of Management Information Systems (see Figure 2).

Figure 2: Overview Publication Outlet Distribution

Within these eight journals, there are five journals from the IS research community, whereas three journals are non-IS journals. This underpins the observation that EMIS is also well discussed in non-IS research disciplines.

4. Qualitative Results

After the quantitative analysis, a second round of qualitative investigation was conducted. For this, all 51 papers have been read thoroughly to decide whether the papers make a clear contribution to EMIS in the context of Information Systems research or not. Again, this analysis was done by two researchers independently. The research results have been compared and differences between the research outcomes were discussed in an additional session. After this qualitative analysis, 14 of the 51 papers have been dismissed. This means that 37 papers remain in consideration.

These 37 papers have been classified according to their research contribution to EMIS. A classification helps to differentiate objects in their properties, and allows a specific grouping of similar objects with common attributes. (Engelien, 1971) For the 37 papers, a classification of four classes has been established:

- Case Study
  All contributions dealing with the application of EMIS in a certain environment or industrial practice
- Strategic Information Systems
  All contribution considering strategic aspects of planning, developing, and implementing EMIS in practice
- EMIS Design
  All contributions discussing the design of EMIS, for example architectural, conceptual, and organizational aspects of EMIS
- EMIS Selection
  All contributions with emphasis on the selection of an appropriate EMIS for a specific application environment

For the distribution of the search results among the different classes (see Figure 3).
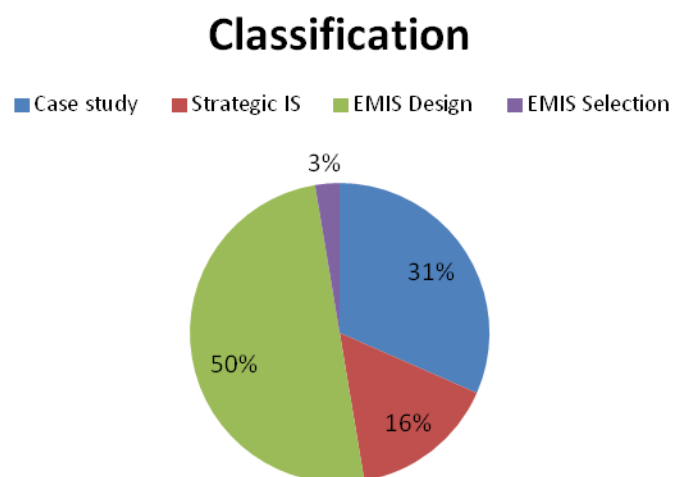
Figure 3: Classification of search results

The majority of the contributions deal with aspects of the EMIS design (50%). The reason for this might be the focus on the design of information systems in general in Information Systems research. Nearly one third of the contributions are case studies, which describe the application of EMIS in practice. This leads to the assumption, that there are a significant number of companies having an EMIS in place. The strategic aspects of EMIS are only discussed in 16% of the contributions. This fraction seems rather low, especially since the management of environmental issues is, in general, a strategic issue in companies. This observation leads to the opinion that the support of environmental issues in a company by information systems has not yet reached the strategic level. Only one paper (3%) considers the appropriate selection of an EMIS for a company in a certain industry environment. This might be linked to the fact that the objectives of an EMIS are often linked with other business applications like Enterprise Resource Planning (ERP) systems, for example. Therefore, the isolated selection of an EMIS seems not to be the standard case.

In the following section, every class of search results is discussed in detail to give more insights to the specific topics considered.

4.1 Case Study
In the class of case studies, 11 papers have been identified (see Table 1):

Authors	Paper
Wong, Christina W. Y.; Lai, Kee-hung; Cheng, T. C. E.	Value of Information Integration to Supply Chain Management: Roles of Internal and External Contingencies (Wong, Lai, & Cheng, 2011)
Wacker, Chris	CAN RIM SAVE THE WORLD? (Wacker, 2010)
Venkatraman, Santosh S.	The Dark Green Side of Information Technology (Venkatraman, 2011)
Tiwana, Amrit; Konsynski, Benn; Bush, Ashley A.	Platform Evolution: Coevolution of Platform Architecture, Governance, and Environmental Dynamics (Tiwana, Konsynski, & Bush, 2010)
Rikhardsson, Pall M.	Information systems for corporate environmental management accounting and performance measurement (Rikhardsson, 1998)
Nigel P. Melville	INFORMATION SYSTEMS INNOVATION FOR ENVIRONMENTAL SUSTAINABILITY (Nigel P. Melville, 2010)
Maier, Jerry L.; Rainer, R. Kelly [JR.]; Snyder, Charles A.	Environmental Scanning for Information Technology: An Empirical Investigation (Maier, Rainer, JR., & Snyder, 1997)
Lusk, Edward J.; Opierzynski, Ralf; Halperin, Michael; Zhuo, Li	ISO 14000 IT software transfer from Europe to Thailand: Issues to be addressed (Lusk, Opierzynski, Halperin, & Zhuo, 2006)
Chin, Kristine	Organize environmental data (Chin, 1999)
Chia, Lei; Jones, Kiku G.; Lederer, Albert L.; Li, Pengtao; Newkirk, Henry	Environmental assessment in strategic information systems planning (Chia et al., 2005)

E.; Sethi, Vijay	
Erek, Koray; Schmidt, Nils-Holger Zarnekow Rüdiger Kolbe Lutz M.	Sustainability in Information Systems: Assortment of Current Practices in IS Organizations (Erek & Schmidt, 2009)

Table 1: Search Results for Case Studies

These case studies cover the different industry sectors (production industry, service industry, software industry) and different application regions (US, Europe, Thailand). It can be seen that the case studies are distributed in a very isolated manner, and do not lead to general insights about success factors of EMIS implementations. There is a lack of broad, multisite case studies to improve the understanding of determining factors of implementing EMIS in specific industry settings or in relation to certain industry regions concerning different environmental requirements.

4.2 Strategic Information Systems

In the section of Strategic Information Systems, six papers have been identified (see Table 2):

Authors	Paper
Walters, Bruce A.; Jiang, James J.; Klein, Gary	Strategic information and strategic decision making: the EIS/CEO interface in smaller manufacturing companies (Walters, Jiang, & Klein, 2003)
Schmidt, Nils-Holger; Erek, Koray; Kolbe, Lutz M.; Zarnekow, Ruediger	EXAMINING THE CONTRIBUTION OF GREEN IT TO THE OBJECTIVES OF IT DEPARTMENTS: EMPIRICAL EVIDENCE FROM GERMAN ENTERPRISES (Schmidt, Erek, Kolbe, & Zarnekow, 2011)
Khani, Naser; Nor, Khalil Md; Bahrami, Mojgan	IS/IT capability and Strategic Information System Planning (SISP) Success (Khani, Nor, & Bahrami, 2011)
Hazardous Waste Consultant	Justifying an Environmental Management Information System (Hazardous Waste Consultant, 2001)
Benitez-Amado, Jose; Nieves Perez-Arostegui, Maria; Tamayo	INFORMATION TECHNOLOGY-ENABLED INNOVATIVENESS AND GREEN CAPABILITIES (Benitez-Amado, Nieves Perez-Arostegui, & Tamayo-Torres, 2010)
Hazardous Waste Consultant	EPA Updates Its Position Statement on Environmental Management Systems (Hazardous Waste Consultant, 2006)

Table 2: Search Results for Strategic Information Systems

Strategic aspects of EMIS can be considered, as well discussed, in the current Information Systems research. However, the linkage to the rising requirements of strategic aspects in

environmental issues for a company is missing. Therefore, the current research state reflects the "older" impact of environmental issues well, but does not reflect the future of environmental analytics and reporting.

4.3 EMIS Design

EMIS design is the largest group of search results. In this class, 19 papers have been identified (see Table 3):

Authors	Paper
Takeuchi, Toshihiko; Yazu, Yusuke; Sakuma, Akiyuki	Integrated environmental management process applying genetic algorithm (Takeuchi, Yazu, & Sakuma, 1999)
Stylianou, Antonis C.; Kumar, Ram L.	AN INTEGRATIVE FRAMEWORK FOR IS QUALITY MANAGEMENT (Stylianou & Kumar, 2000)
Rizzoli, Andrea E.; Davis, J. Richard	Model and data integration and re-use in environmental decision support systems (Rizzoli & Davis, 1998)
Renner, Rebecca	Environmental e-data comes to drinking water (Renner, 2004)
Moore, Margery A.	Through the Eye of a Needle: The Importance of Portals to Environmental Information Management (Moore, 2003)
Moore, Margery A.	A Strategic, Systems Approach to Understanding Environmental Management Information Systems (Moore, 2002)
Ming-Hsiang Tsou	Integrating Web-based GIS and image processing tools for environmental monitoring and natural resource management (Ming-Hsiang Tsou, 2004)
Kuo, Ben N.; Dick, Geoffrey N.	THE GREENING OF ORGANISATIONAL IT: WHAT MAKES A DIFFERENCE? (Kuo & Dick, 2010)
Kefalas, A. G.	Environmental Management information Systems (ENVMIS): A Reconceptualization (Kefalas, 1975)
John Wang; Qiyang Chen; Li-Chun Lin	FOCUSING ON ENVIRONMENTAL SUSTAINABILITY FOR THE IT SECTOR (John Wang, Qiyang Chen, & Li-Chun Lin, 2013)
Tavana, Madjid	Fahrenheit 59: An environmental decision support system for benchmarking global warming at Johnson Space Center (Tavana, 2008)
Elliot, Steve	Transdisciplinary Perspectives on Environmental Sustainability: A Resource Base and Framework for ITEnabled Business Transformation (Elliot, 2011)
El-Gayar, Omar F.; Fritz, Brian D.	Environmental Management Information Systems (EMIS) for Sustainable Development: A Conceptual Overview (El-Gayar Omar, 2006)
Chowdhury, Gobinda	Building environmentally sustainable information services: A green is research agenda (Chowdhury, 2012)

Bullinger, H.-J; Steinaecker, J. von; Weller, A.	Concepts and methods for a production integrated environmental protection (Bullinger, Steinaecker, & Weller, 1999)
Ahituv, Niv; Zif, Jehiel; Machlin, Isaac	Environmental scanning and information systems in relation to success in introducing new products(Ahituv, Zif, & Machlin, 1998)
Afgana, Naim H.; Cvetinović, Dejan B.; Andre, Paul	Sustainable Resilience of Company Management System (Afgana, Cvetinović, & Andre, 2011)
Zheng Weijun, Zmud Robert	Structuring Environmental Scanning and Organizational Information Interpretation: An Organization-Level Contingency Model (Zheng Weijun)
Hasan Helen, Ghose Aditya Spedding Trevor	IS Solution for the Global Environmental Challenge: An Australian Initiative (Hasan Helen, 2009)

Table 3: Search Results for EMIS Design

Design artifacts range from specific algorithm for environmental management over information systems architecture to usage concepts like portals for environmental management. These design artifacts deliver a base for the planning and development of EMIS. However, an overall concept for the design of EMIS according to specific requirements is missing. For example, there is a difference between implementing EMIS in small and midsize companies in comparison to implementing EMIS in large companies. This aspect is not yet covered. For the achievement of a holistic picture of EMIS design, more generalization has to be done to feed the ground for reference artifacts as a design blueprint for future EMIS implementations.

4.4 EMIS Selection
In EMIS selection, only one paper was identified (see Table 4):

Author	Paper
Gilbert, Jill Barson	Selecting software for environmental compliance (Gilbert, 1999)

Table 4: Search Results for EMIS Selection

This work considers the selection of EMIS for the application in environmental compliance and covers only one specific part of an EMIS implementation. Unfortunately, there is no work on EMIS selection for certain industry sectors or specific application requirements.

4.5 Outline for a Research Agenda
From the qualitative analysis of the existing contribution the EMIS in Information Systems research, several open directions for future research can be observed.

First, the current state of research does not reflect the strategic importance of environmental issues in current and future companies. On one hand, more and more companies try to communicate their environmental impact to their customers in order to receive positive attention,

and to be recognized as responsible companies. On the other hand, it can be observed, that from a legislative perspective, more duties to companies in the future will arise in order to report their environmental impact. For both issues, there is no discussion in the scientific community yet on how to address these challenges.

Second, industrial practice in environmental issues shows that methods for measuring and collecting information on environmental objects are getting more sophisticated and are increasing. A prominent example for this is Smart Metering in the energy industry, where information on energy consumption is metered directly in private households to gain knowledge about the use of energy. Based on these analytics, the provisioning of energy can be adapted to the specific need of the particular household. These data cannot be integrated seamlessly in EMIS to achieve a holistic view from an energy provider's perspective. To achieve this, more research has to be done on aspects like data and process models for energy analytics, privacy, and predictive analytics.

5. Summary and outlook

The aim of the paper was to provide an overview of the current research status of Environmental Management Information Systems in Information Systems research. For this, a structured literature study was conducted. All major publication outlets for Information Systems research have been investigated for relevant publications on EMIS. In a first quantitative analysis, 51 publications could be identified. It could be shown that research on EMIS had its peek from 1997 to 2011. Furthermore, EMIS topics are well discussed in non-IS academic publication outlets. After a further qualitative analysis, 37 papers remain for the discussion of further research directions. These 37 papers could be separated in three different core topics: case studies, EMIS design, and strategic information systems. It could be shown that the focus on research is on the design of EMIS, but the design does not reflect current developments in environmental research areas like energy, for example. This leads to a call for getting back into the scientific discussion of EMIS with a clear focus on interdisciplinary approaches that address current and future challenges in environmental reporting and analytics.

As further research, the investigation should be broadened to other scientific disciplines to identify EMIS relevant topics as design foundation for future conceptualizations. Moreover, a practical view from the industry is necessary to address relevant topics in very specific and dynamic markets like energy provisioning.

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