Trends in Environmental Management Systems Research. A Content Analysis

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Abstract – Environmental Management Systems (EMS) represent a solid opportunity for companies that voluntarily undertake a path towards the adoption of environmental protection policies. Many studies investigated the link between EMS and improvement of environmental performance, demonstrating how the adoption of an international standard as ISO 14000 or EMAS guarantees the company an improvement in its performance and an increase in transparency towards stakeholders. However, scientific research in this field reflects the strong variability due to the breadth and diversity of sectors in which the two international standards can be adopted. The aim of this work is to analyse, through textual statistics and text mining methods, the trends that characterize scientific production, highlighting most debated topics useful for developing new research perspectives in this research field.

Keywords – EMAS; Environmental Management Systems (EMS); ISO 14000; text mining; textual statistics

1. INTRODUCTION

By the end of the 1980s, there has been a growing interest in environmental issues, not only by government institutions and consumers, but also by the private economic sector. The industry began to recognize the complexity of the environmental problems connected to its business and implications for the business management of the environmental issue, starting to question on possible perspectives to reconcile the economy of its business with the environmental impact of its activities [1].

Many companies, trying to anticipate the rapidly evolving environmental regulations, began to adopt voluntary pollution prevention practices, with the aim of reducing or eliminating pollutant emissions. These initiatives were based on the control of production processes and on the control of polluting sources that were introduced into the production cycle. This phenomenon represented one of the first steps towards the development of a preventive approach to the environmental issue, with respect to the vision previously considered of control of harmful substances released into nature [2].

The birth of environmental management systems is therefore attributable to a variation of the inspiring principles of the American and European environmental policy, which since the 1990s has seen the progressive affirmation of a new approach to environmental protection in

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relation to the rules of the market, and the conjugation between the environment and the competitiveness of businesses according to the principles of Sustainable Development.

Since then, there has been a strong evolution of voluntary environmental management systems. Nowadays, both ISO and EMAS, represent a solid and voluntary approach to guarantee environmental protection beyond strict compliance of the law, within a framework characterized by an increased transparency towards stakeholders who interact with the organization itself (customers, suppliers, employees, citizens, public administrations, credit institutions, etc.).

Due to its mostly practical connotation, the scientific debate surrounding EMS has simultaneously focused on a broad set of diverse aspects which characterize voluntary standards. For example, Wang *et al.* [3] and Campos *et al.* [4] investigated the application of EMS in specific sectors, while other authors as Stevens *et al.* [5], focused on the types of organizations which adopt an EMS and on the reasons that lead these organizations to undertake a voluntary path of environmental management [6]. Some authors dealt more specifically with businesses, and in particular with small and medium-sized enterprises [7], and in this context, Vázquez-Berna [8], through an academic review, analysed the impacts which affect companies adopting an EMS.

However, these reviews analysed a limited number of papers. For this reason, using the methodology of text mining, this work aims to adopt a broader approach, which takes into consideration most of the scientific production in the EMS - without distinction of sectors, types of organizations or specific aspects of the phenomenon - analysing trends, underlining the most debate topics, to develop new pathways for future research in EMS.

The paper is organized as following: section 2.1. and 2.2. describe data collected for the constitution of a corpus on which to carry out the analyses, while the methods are described in section 2.3. The results are explained in section 3, followed by discussion in section 4 and conclusions in section 5.

2. MATERIAL AND METHODS

2.1. Data Collection

According to Feldman and Sanger [9], data collection is represented by a set of processes aimed at identifying a corpus, related to the topic to be analysed. In this case we used SCOPUS database, one of the largest abstract and citation databases for academic literature. Thanks to the database functions it was possible to select the types of contributions, such as articles, reviews and conference papers and the reference period, that was selected from 1995 to today.

Preliminarily, the query with the term ‘Environmental Management System’ was used, which resulted in 3440 documents. The research was further refined with the introduction of other similar and commonly used terms for the definition of the topic, as well as the specific terms of the two major certification standards. Primary subject areas were also progressively added in order to achieve a *corpus* of 401 documents that could be numerically significant and at the same time qualitatively centred with the subject of investigation. Table 1 shows the steps and queries applied for the search.

TABLE 1. QUERIES ON SCOPUS DATABASE – MARCH 2021

Keywords	Boolean Operator	Subject Areas	No. Documents
Query 1			3440
Environmental Management Syst*	–	–	
Query 2			1525
Environmental Management Syst*	–	Environmental Sciences	
Query 3			1411
EMS	OR	Environmental Sciences	
Environmental Management Syst*		Social Science	
Query 4			203
EMS	AND	Environmental Sciences	
Environmental Management Syst*		Social Science	
		Business, Management Accounting	
		Economics, Econometrics and Finance	
Query 4			401
EMS	AND	Environmental Sciences	
Environmental Management Syst*	AND	Social Science	
ISO 14001	OR	Business, Management Accounting	
EMAS		Economics, Econometrics and Finance	

A dataset was therefore created containing the abstract, author's keywords and source of each article. It was also possible to download each contribution to create the corpus on which to apply the methods for this analysis.

2.2. Overview of Articles

Over the considered period (1995–2020), the number of published researches shows a growing trend, with the exception of 2015 in which scientific production (8) was less than the annual average of 14 published articles (Fig. 1).

Fig. 1. Scientific production on EMS (1995–2021).

An overview of the journals in which the selected articles were published shows a correspondence between the corpus and the object of investigation, since they all deal with clean production, environmental issues, sustainability, management and business strategy (Table 2).

TABLE 2. SCIENTIFIC PRODUCTION BY SOURCE

Ranking	Journal title	Published research
1	Journal Of Cleaner Production	57
2	Environmental Quality Management	14
3	Sustainability	14
4	International Journal of Life Cycle Assessment	12
5	Corporate Social Responsibility and Environmental Management	11
6	Business Strategy and The Environment	10
7	Greener Management International	10
8	Corporate Environmental Strategy	9
9	Journal of Environmental Management	8
10	Environmental Management	6

2.3. Methods

The methodologies used in this work were Textual Statistics and Text Mining methods. These methods were chosen in order to analyse the real scope of the Environmental Management Systems, to focus the investigation on the central elements of their discussion and on the trends that characterized scientific production in that field.

Textual statistics is defined as the mathematical study of texts meant as a collection of distinct items which can be compared through the analysis of their frequency [10]. It is widely used, especially in linguistic research [11], [12], and it employs a variety of methods, ranging from procedural processing, in which the texts are not exposed to any prior analysis, to cases in which linguistic knowledge can be used to classify textual types with precise meaning [13].

The first step of this study was to analyse the frequencies of author's keywords in the selected corpus. The analysis has been carried out with *ATLAS.ti* [14], [15] a data analysis

software for qualitative research that allows to carry out various investigations on the data constituting the corpus showing in a graphic form the properties and relationships between the information in order to give meaning and structure to the data.

All keywords with a frequency higher than 4 have been categorized into five different argumentative dimensions (Table 3).

TABLE 3. KEYWORDS CATEGORIES

Argumentative dimensions	Keywords
Management	ems, eco-management, policy, benefit, strategy, barrier, innovation, control, change, ecological, improvement, organization
Standards	ISO, EMAS, certification, quality, scheme, model, integration, audit
Assessment	Assessment, performance, lca, indicator, evaluation, implementation, drivers, integration, material, factors, accounting, impact
Application	Product, production, energy, pollution, waste, design, process
Business	Industry, business, sme, sector, company, enterprise, corporate, financial, local, china, malaysia, intentional, manufacturing, supply

The second phase of the study was the investigation on the elements that characterize scientific output related to EMS. The method chosen for this analysis was text mining [16], through which it is possible to explore and analyse vast volumes of textual data in order to define, themes, templates, and other attributes. According to Feldman and Sanger [9], the use of text mining to probe documents, includes three distinct phases:

1. Constitution of corpus;
2. Pre-processing and cleaning;
3. Review and assessment of information.

At this stage, some information contained in the corpus may be irrelevant for the analysis [17]. For this reason, pre-processing and cleaning phase removes from the corpus all the insignificant words that commonly appear in the language, such as prepositions, conjunctions, pronouns, and punctuation. It was also necessary to clean up data from the characteristic terms of scientific articles, such as the words ‘journal’, ‘review’, ‘paper’, but also ‘DOI’.

According to Bazeley [18], the argumentative dimensions and the relative keywords (Table 3) have been used to code the corpus. Coding is a basic ability for qualitative research, because it offers access to evidence that can be used to question results, verify hypotheses, and draw conclusions. At the most basic level, naming a code creates a mark that connects data to the concept, and the idea to all the data relating to that idea [19]. The codification of the articles contained in the corpus allowed us to extract from it all sentences which contained those words.

An analysis of co-occurrence codes [20], [21] was carried out for each argumentative dimension (for more detailed information see Annex), to highlight the codes that were applied to the same quotation and to find out which topics are mentioned simultaneously and how often. This approach allows to analyse the trend topics of a very high number of papers concerning EMS, but at the same time, thanks to the analysis of the co-occurrence tables, to address the analysis towards the study of specific aspects of interest.

In this case, the next phase was represented by the analysis of the quotations extracted selecting the pair of codes with the highest frequency. To visualize the results, we chose the

Word Clouds approach. This style of representation is utilized in a variety of scenarios to provide a clear summary of the most commonly occurring terms in a text. Moro *et al.* [22], for example, used this methodology to determine the scope of the literature and define the notion of ethnic marketing, which is characterized by considerable heterogeneity. Other applications can be found in the biomedical field, as well as in the rapidly growing fields of Big Data and computer science [23]. It is also defined as a useful summary for determining the amount and type of subjects present in a body of text [24], [25] and it is obtained by positively correlating the font size of the represented words with its frequency in the text.

3. RESULTS

The corpus, consisting of over 120 000 words, was analysed using the *ATLAS.ti* software. For each argumentative dimension it was possible to establish the main topics covered and give a selection of most representative articles on topics results. It was also possible to choose minimum threshold values, excluding words less frequently used and focusing attention on the most used words. What derives from this is a clear sign of the most discussed issues in every single dimension.

3.1. Management

Fig. 2 relates to the argumentative dimension of Management (see Annex 1 – Table 6)

Fig. 2. Management argumentative dimension word cloud.

The relationship between the EMS and the corporate organizational structure is evident. The goal of EMS adoption is to help organizations in improving its environmental performances, complying with laws and managing major environmental risks, liabilities, and impacts, which should be identified and minimized [26]. In this sense, the adoption of an EMS mainly depends on company culture, nature of business, extent of internal environmental maturity, and the actual organization situation and conditions [27], [28]. In the extracted scientific articles, the implementation of EMS is declined in several aspects, among which the most relevant are the environmental policy development [29]–[31], employee and management training [32]–[34], management review [35], auditing practice [36], [37] and corrective action [38].

3.2. Standards

Fig. 3 relates to the argumentative dimension of Standards (see Annex – Table A7). The topics most treated are related to the characteristics of the two international environmental management standards and their diffusion [39]–[44].

Fig. 3. Standards argumentative dimension word cloud.

Both certifications have been the subject of studies on their effectiveness in terms of environmental performance, in which a better result was found compared to companies that do not adopt an environmental management system [45]. Particular emphasis is given to issues related to motivational factors which influence decisions on the adoption of EMS standards by organizations and companies [46]–[50].

3.3. Assessment

The third argumentative dimension (see Annex – Table A8) is related to Assessment issues (Fig. 4). The most significant evaluation carried out in this dimension is represented by environmental performance assessment. Some articles consider the evaluation of company performance as a valid tool to identify the cause of their environmental impacts along the entire value chain, in order to improve the environmental performance itself [51]–[54]. At the same time, research investigate firms which adopt an EMS from an economic and social performance point of view [55]–[58]. Another issue is quality and how it impacts on the environmental performance of companies [59], [60].

Fig. 4. Assessment argumentative dimension word cloud.

3.4. Application

Fig. 5 shows the Application word cloud (see Annex – Table A9). All results are related to physical materials and energy which intervene in the whole industrial process as for extracting, processing, and consuming. Main arguments are in fact materials, product/process, waste generation, energy consumption but also design.

Fig. 5. Application argumentative dimension word cloud.

Many authors point out how the implementation of an EMS can increase productivity, in terms of refined processes, cost savings, waste reduction or reduction in raw material and energy consumption [61]–[63]. Adopting an EMS typically entails the monitoring of a wide range of production processes, as well as the implementation of pollution, energy and waste management systems [64]. Companies with environmental management systems are more likely to implement technical innovations that change their production process [30], [65] as well as product design with life cycle analysis has a considerable positive effect on environmental product and process innovations [66].

3.5. Business

The last result of the analysis concerns the topic of business implementing EMS (see Annex – Table A10). In the word cloud, the terms that define industry and companies are evident, but also the main sectors, which scientific production has dealt with. Many authors analysed the adoption of EMS in food sector [67]–[70]. For example, Salim *et al.* [71] examined factors determining EMS adoption within the food and beverage industry, while Ormazabal *et al.* [72] pointed out how food companies with an environmental management standard tend to have a more developed system and a greater presence of environmental tools and actions.

The second main field of study is chemical industry [27], [73]. In this context, Evangelinos *et al.* [74] examined the ways in which various factors affect the choice of the chemical industry in their adoption of an EMS, while Yaqoob *et al.* [75] underlined the role of legislation enforcement and strategic environmental assessments to encourage chemical industry to adopt an effective EMS.

Thanks to the word cloud it is also possible to note that one of the main aspects of this argumentative dimension is waste production, which is considered by several authors to be one of the main reasons that lead companies to adopt an EMS [76]–[80].

Fig. 6. Business argumentative dimension word cloud.

4. DISCUSSION

The approach of text mining for the analysis of Environmental Management Systems research allowed to build a framework useful for in-depth investigations in this field. The definition of argumentative dimensions based on the author's keywords allowed the coding of the corpus and the construction of co-occurrence tables useful for tracing not only the trends, but to identify connections between all the defined topics, and to develop new research perspectives in this research field.

It should also be noted that in all the word clouds, with the exception of the specific argumentative dimension of the standards, the word clouds “ISO” is present, while the EMAS

is not. This peculiarity derives mainly from the diffusion of the two standards. The international scope of the former is therefore reflected into the scientific production.

Of the five argumentative dimensions that characterize the corpus, the one that had the greatest response, in terms of quotation, is Application with 1253 extracted quotations. This result gives a clear indication of how scientific research focuses more on aspects related to relationship between EMS and productivity, reduction of waste and energy consumption. However the aspects related to performances assessment, both environmental, economic, and social, of companies which adopt a management system, receives less attention.

In the corpus made up of over 400 scientific papers the second main indication is represented by Management dimension. This result allows us to highlight how aspects such as company culture, environmental policy development, employee and management training, auditing practice and corrective action appear to be of great interest to researchers in this field. In addition, there is also strong feedback on topics related to standards and their attributes (1078 quotations), while the arguments related to the specific characteristics of the companies that adopt an EMS arouse less interest (632 quotations).

5. CONCLUSION

The analysis made it possible to arrive to a clear definition of the most debated issues in the context of Environmental Management Systems. If from a managerial point of view the adoption of an EMS depends on the organizational structure of business, the two standards ISO and EMAS allow a clear improvement in the environmental performance of companies. At the same time, many studies focus on the strong need of a broad environmental assessment linked to production processes, as well as pollution, energy consumption and waste management issues.

This study achieved the objective of providing a picture of the current research in the field of EMS, testing a research tool useful for subsequent more detailed analyses and debates on this research topic.

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ANNEX

TABLE A1. MANAGEMENT CO-OCCURRENCE.

	barrier	benefit	change	eco- management	ems	improvement	innovation	organization	policy	strategy
barrier	0									
benefit	30	0								
change	50	16	0							
eco- management	5	0	1	0						
ems	309	235	381	61	0					
improvement	28	36	156	3	702	0				
innovation	23	7	100	4	262	57	0			
organization	67	103	323	18	1147	257	127	0		
policy	18	11	126	6	494	149	61	195	0	
strategy	58	33	164	4	464	130	155	389	162	0

TABLE A2. STANDARD CO-OCCURRENCE.

	audit	certification	emas	integration	iso	model	quality	scheme
audit	0							
certification	38	0						
emas	284	53	0					
integration	9	2	20	0				
iso	212	490	1077	103	0			
model	11	22	31	34	291	0		
quality	30	48	29	61	361	101	0	
scheme	316	12	363	4	167	8	15	0

TABLE A3. ASSESSMENT CO-OCCURRENCE.

accounting	assessment	driver	evaluation	factor	impact	implementation	indicator	lca	material	performance
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accounting	0										
assessment	19	0									
driver	5	10	0								
evaluation	12	73	12	0							
factor	22	46	41	57	0						
impact	29	443	45	153	204	0					
implementati on	17	67	102	108	376	298	0				
indicator	9	68	10	124	48	177	98	0			
lca	5	187	1	26	15	167	15	21	0		
material	29	48	7	17	52	131	43	53	39	0	
performance	92	154	110	374	273	817	455	693	34	82	0

TABLE A4. APPLICATION CO-OCCURRENCE.

	design	energy	pollution	process	product	waste
design	0					
energy	32	0				
pollution	11	110	0			
process	230	179	144	0		
product	339	415	210	1253	0	
waste	55	443	222	282	483	0

TABLE A5. BUSINESS CO-OCCURRENCE.

	business	china	company	corporate	enterprise	financial	industry	local	malaysia	sector	sme	supply
business	0											
china	35	0										
company	434	36	0									
corporate	203	45	323	0								
enterprise	99	26	120	42	0							
financial	26	1	48	39	9	0						
industry	238	113	629	207	134	31	0					
local	54	13	150	37	38	4	107	0				
malaysia	19	10	53	12	6	1	47	1	0			
sector	127	22	401	52	52	9	546	56	23	0		
sme	14	0	28	7	32	3	8	4	5	15	0	
supply	72	34	173	79	26	8	155	25	14	74	4	0

TABLE A6. MANAGEMENT WORD CLOUD – FREQUENCIES

Word	Frequency
ems	1357
organizations	525
iso	315
implementation	219
system	149
performance	142
activities	89
aspects	85
practices	81
improve	71
adoption	69
policy	69

TABLE A7. STANDARD WORD CLOUD – FREQUENCIES

Word	Frequencies
iso	1242
emas	1204
ems	328
standards	161
certification	142
companies	128
european	117
scheme	112
audit	96
performance	87
implementation	85
international	82
adoption	79
corporate	78
organizations	69

TABLE A8. ASSESSMENT WORD CLOUD – FREQUENCIES

Word	Frequencies
performance	923
impact	684
ems	238

iso	151
corporate	129
systems	102
business	74
implementation	69
system	69
assessing	63
positive	63
quality	63
manufacturing	59
practices	59
improvement	58
green	57
economic	53
supply	51
adoption	50
chain	50

TABLE A9. APPLICATION WORD CLOUD – FREQUENCIES

Word	Frequencies
process	615
production	457
product	452
ems	164
quality	157
waste	141
innovation	137
which	132
design	115
iso	115
performance	110
system	110
innovations	105
materials	102
development	99
green	98
energy	96
improvement	93

company	88
aspects	86
reduce	82
new	76

TABLE A10. BUSINESS WORD CLOUD – FREQUENCIES

Word	Frequencies
companies	539
industry	325
for	227
iso	133
ems	111
performance	96
sector	56
factors	49
implementation	48
production	46
sustainability	40
standard	36
waste	36
chemical	32
activities	29
business	29
food	28