Some Thoughts on the Notion of Environmental Information Science

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Abstract

Environmental information is important for understanding how our planet is changing and what is the role of human activities in the process of this change. Access to quality environmental information is crucial for developing relevant policies and appropriate practical responses for the global and regional environmental problems. Environmental information systems have been developed for many years to facilitate environmental information creation, organization and access; however, the boundaries of environmental information research are beyond dealing with just the *systems* and can cover various topics under the broad discipline of *environmental information science*. This article reviews the concept of the *science* of environmental information and the topics that might be included in it.

Introduction

There has been a consensus that the key for overcoming global and regional environmental issues is to input real-time and reliable environmental information in environmental decisions "…the developments in today's modern society challenge us to rethink the role of knowledge and information in dealing with environmental challenges" (Mol 2006,Mutshewa, 2007; Briassoulis, 1999; Naess, 1994).

While environmental experts realized the importance of environmental information from the emerging years of environmental sciences, the need for more systematic management of environmental information has received more attention in the past two decades. In recent years, there have been significant technological advancements in environmental information management and it receives continues attention by scientists, information professionals and academic librarians. On the other hand, some academic departments and research groups have emerged with the title of "environmental information science"; nevertheless the fact that whether this discipline and its components are properly defined and understood can still be a matter of discussion. In particular, when we think of "environmental information science" as a discipline that is laying at the intersection of "environmental science" and "information science", the complexity of its nature may raise even more because "information science" itself has many ambiguities in its definition. This

article reflects the authors' thoughts on the notions of environmental information and environmental information science.

Background on Information and Information Science

The essence of “information science” has been a controversial matter in the past several decades. The reason originates firstly from the changing nature of this field and secondly from being associated with many interdisciplinary concepts. Several works have already made attempts to discuss identity and fundamental concepts of information science (e.g. Borko, 1968a; Borko, 1968b; Wellisch, 1972; Brookes, 1975; Brookes, 1980; Wersig and Neveling, 1975; Belkin and Robertson, 1976; Shera, 1977; Belkin, 1978; Herner, 1984; Derr, 1985; Boyce and Kraft, 1985; Salton, 1987; Debons, et al. 1988; Swanson, 1988; Lilley and Trice, 1989; Losee, 1990; Farkas-Conn, 1990; Buckland and Liu, 1995; Hjorland, 1998; Buckland, 1999; Hawkins, 2001; Cornelius, 2002; Raber, 2003; Zins, 2007a). Many of them have defined information science in line with the relationships it has with other fields such as information technology, computer science, human behavior, cognitive concepts, system science, and library science. As “information” itself is an enigmatic concept, the scientific field associated to it has been defined from various perspectives. Back in 1958, the term “information science” was used for the first time in the foundation of Institute of Information Scientists (IIS). Then, information professionals progressively attempted to establish fundamentals and boundaries of their field. However, after the evolution of this new field, the practitioners had not consensus about what it is or should do. At the same time some specialists believed that the discipline called “information science” has not yet attained the status of a true science, “lacking an agreed-upon central topic of investigation and an unambiguous terminology” (Wellisch, 1972, p. 157). In the late 1970s, a variety of works attempted to explain the fundamentals, basic topics and boundaries of this field and to define it as a distinguished scientific discipline. For example, Belkin (1978) suggested a framework for information science and attempted to understand the concept of information from a scientific pathway. Brookes (1980) took a cognitive view to information science and used knowledge models of Popper (1972) to provide a framework for the nature of information science. However, a generally acceptable definition had not yet been formulated for the field, though among the most famous early expressions, the one given by Borko was predominant:

> “Information science is the theoretical discipline concerned with the applications of mathematics, systems design, and other information processing concepts; it is an interdisciplinary science involving the efforts and skills of librarians, logicians, linguists, engineers, mathematicians and behavioral scientists” (1968a, p. 5).

From this perspective he described information science as: “the discipline that investigates the properties and the behavior of information, the forces governing the flow of information, and the means of processing information for optimum accessibility and usability” (Borko, 1968b, p. 3). Interestingly the contemporary definitions also employed the same concept but with considering the essence of technology: “information science is systematic study and analysis of the sources, development, collection, organization, dissemination, evaluation, use, and management of information in all its forms” (Reitz, 2004). In a recent series of studies entitled “knowledge map of information science”, Zins (2007a) had a survey among information scientists in an international panel, composed of 57 leading scholars from 16 countries for exploring the foundations of information science. He concluded:

> “Information Science is the study of the mediating perspectives of universal human knowledge... the mediating perspectives include cognitive, social, and technological aspects and conditions, which facilitate the dissemination of human knowledge from the originator to the user” (p. 339).

What is Environmental Information? How it can be used?

“Environmental information” could be defined somewhat analogous to the definition of “information” and “environment”: sorts of data which convey a meaning in order to inform people about the present and past physical, chemical, biological and human processes in the surface and near-surface earth, its waters and atmosphere. In the literature, there are other definitions, from which Dosa (1980) gave one of the early compendious: “Environmental Information is the process of transferring data and information from source to user in any field of knowledge of activity applicable to environmental problem solving”. This expression indicates that environmental information is wide in its scope. There are several perspectives to the wideness of the range of information that could fall within the classification of “environmental”. According to the UK Environmental Information Regulations (2004), environmental information is information on the state of the environment and factors effecting the environment; information on measures such as policies, legislation, and economics; and information on the state of human health, safety, culture, and life condition, where they are affected by environmental factors.

Therefore, one can state that environmental information is not only about the environment itself, but also it is about the factors that affect the environment, as well as policies, plans and laws. Yet, creating, organizing, archiving and retrieving environmental information is full of complexity and intricacy. This complexity, according to Jankowska (2000) arose from the nature of environmental information, which in one hand cuts across topics in many disciplines, and on the other hand; is generated and gathered, by different groups, peoples and entities:

scientists, government agencies, commercial publishers, environmental movement groups, professional and private organizations, environmentalists, information experts, and librarians. In addition, environmental information and knowledge are created and disseminated by groups with interests.

Environmental information can be better understood by Zins's notions on “data”, “information” and “knowledge” from the perspective of what he calls “universal domain”, as he believes these phenomena have two modes of existence: subjective and universal. Subjective domain refers to subjects and the individual's internal world (i.e., as a thought) while universal domain refers to objects or things (e.g., as it is published in printed or electronic books, presented in digital libraries, and stored in electronic devices) (Zins, 2007b). In the universal domain “information is a set of signs, which represent empirical knowledge, and knowledge is a set of signs that represent the meaning (or the content) of thoughts” (p.487). Environmental knowledge is in fact, the environmental information, which is used in a cognitive structure and in an applicable way for environmental problem solving. Environmental information is needed to build environmental knowledge. Therefore, in order to facilitate the information-to-knowledge flow for environmental problem solving, two sorts of instruments might be needed simultaneously: first, effective *policies* to identify what sorts of information are needed, how the information should be prepared and in which ways should be applied; and second, appropriate *systems* for creation, management and interpretation of the information.

Environmental information policies

Effective environmental problem solving depends on the appropriate information being brought in action for bearing a problem (Richards and Kabjian, 2001). Access to relevant information can help to improve the work of keeping the environment under review. Most environmental decision makers and policy developers depend upon the instant access to quality information for every aspect of their work. To maintain this, strong information policies are required. Environmental information policy is a collection of principles, guidelines, rules, regulations and procedures for the generation, management and utilization of environmental information. It occurs among industries, corporations, organizations and institutions for clarifying their strategies toward the information on their environmental objectives and performance. In the absence of an appropriate environmental information policy, the creation and distribution of information will solely depend on the individuals to decide what they do with the information they have (Mutshewa, 2007).

The most important function of environmental information policy is determining the quality of access to appropriate environmental information. Making policies toward increasing the accessibility of environmental information can make significant difference not only in scientific research, but also in pushing decision makers towards better environmental governance.

Environmental information systems

To facilitate the flow of environmental information from data sources to the decision makers, and to provide the necessary analyses that are required to give them adequate information, environmental information systems are appeared (Fraser and Hodgson, 1995). The term Environmental Information System (EIS) refers to an integrated set (or system) of components like people, data records and activities for collecting, storing, processing and presenting environmental information. In a more simplified explanation, Haklay defines EIS as “a collection of data sets and information that have some relevance for the study and/or monitoring and/or exploration of the environment” (1999, p. 3). In accordance with the growing demand for access to environmental information, there is a growing need for well-developed environmental information systems. Experiences of geological, hydrological, climatic, atmospheric, and wildfire hazards such as earthquakes, landslides, volcanic eruption, floods, tsunamis, droughts, tornados, forest fires show how much timely and accurate environmental information can make a difference.

Environmental information science as a field of study

The expansion of new dimensions in environmental research in one hand, and the recent developments in the information science and technology on the other hand, has dramatically changed the approaches in which environmental information is created, managed and analyzed. The huge increase in the scale, diversity and complexity of environmental data indicates why more attentions to environmental information science as a scientific field are essential. This need was correctly understood in the early 1990s when Stafford et al. anticipated the emergence of a new discipline for scientific information management of environmental science as a result of evolving data management far beyond its traditional scope: “We anticipate that this evolution will lead to the emergence of scientific information management` as a discipline” (1994, p. 4). The scientific field for of environmental information research has two main characteristics. First, it has interdisciplinary nature because it is used by environmental scientists and practitioners and is generated by people from diverse disciplines for diverse purposes (Palsson, 2006). Second, it is strongly connected to the information technology (IT), because IT enables unprecedented opportunities for discovery and new ways to do research in this area (Mark, 2000). This connection originates from the application of computing in the environmental information creation, modeling, storage and retrieval, as well as in the relevant products and services. In addition, IT provides a context for facilitating the connections of environmental information research with other fields of inquiry. Palsson (2006) believes every distinguished research field could be defined by listing its components and the problems it addresses.

Naming, definition, and recognition: the ontological challenges

In 2005, seven years after Stafford et al. (1994)'s statement about the creation of a discipline for environmental information management, Frondorf et al. (2005) went beyond anticipation and explicitly mentioned about environmental information science as “a new science planned for future”. In their report named “Future science direction: environmental information science plan”, they defined the field as the development and application of interdisciplinary approaches for understanding environmental phenomena at all level of complexity (p. 1).

Their definition also emphasized on the interdisciplinary nature of the field. It seems the main ontological challenge of this field is to explore approaches for effectively linking information science principles and methods with the complex environmental systems and processes in an interdisciplinary way. Nevertheless, the basic problem in the ontology of environmental information science as a field is confusing it with “environmental informatics”. Environmental informatics has been already introduced as a new research domain (Husar et al., 1990; Avouris and Page, 1995; Huang and Chang, 2003; Voigt, 2008) and has been commonly defined concerning the environmental information systems. Haklay stated that: “environmental informatics is the field that deals with the development, management and research on environmental information systems” (1999, p. 15). The common perception of environmental informatics is the application of database, information system, software and generally computer science in the environmental research, as mentioned by Jones and Gries: “environmental informatics lies at the intersection of environmental science and computer science, and enables new advances in environmental research through the application of computing techniques” (2010, p. 1). However, environmental information science conveys a broader view of a science which environmental informatics is a significant component of it. This *science* provides theoretical basics for environmental informatics and tries to define environmental concepts in the context of their usability for information systems. It goes beyond solely developing and using information systems, and explores phenomena of which environmental information transforms into the environmental knowledge and studies any concept involving in this process like as systems, collections, materials, people, organizations, and societies. It is concerned with the body of knowledge relating to the environment as well as the management, technological tools and human related factors affecting it. Environmental information science not only investigates the organizing of information resources; but also has a general perception of time, place, environment, people, context, and methods related to the creation, dissemination and utilization of environmental information.

Aims and objectives of the field

The objective of environmental information science is generation, acquisition, management, utilization, and analysis of collections of environmental information in order to facilitate the flow of information into the process of environmental planning, policy developing and decision-making, as well as establishing an integrated scientific approach to the study of various phenomena involving in this process. Achieving this objective may include the followings.

Environmental information creation/acquisition and management

While the amount of available information is growing in almost all areas of environmental science through increasing monitoring practices, information storage capacity, information transport and scientific understanding of environmental phenomena (Mol, 2006), the new developments in computational technologies, on the other hand provides new and powerful infrastructure for the management of existing information. However, regardless of technological developments, the problem of dealing with this huge ever-growing amount of information and appropriately managing it is still a complicated task. Mutshewa (2007) argued that the fundamental problems of the environment do not rest with the planning process or the administration, but with the manner in which the information that is needed for planning is managed. He believes the most difficult and time-consuming mission performed by planners was found to be collecting information to support the processes resulting in the environmental planning.

Distribution and dissemination of environmental information

Erlandsson and Tillman stated that “environmental information does not just suddenly appear; it needs to be collected, compiled, and then disseminated” (2009, p. 800). Distribution and dissemination of high quality environmental information through systems and frameworks is an important aspect of sustainable development. Dissemination processes are deemed to be effective when it provide users with opportunities to access the information they require (Moxen and McCulloch, 1999).

Management of the environmental information quality

Environmental information science has responsibility to investigate the quality of information. According to Palsson (2006) an important issue that should be considered in data quality assessment is how to deal with uncertainty. New structures for environmental information management allow further dissemination of environmental data, which leads to additional questions related to the quality/uncertainty of the data (Delavar and Devillers, 2010). Palsson (2006) indicated that this issue along with other aspects such as reliability, accessibility,

and relevance concerns both the information content and how the information is captured, stored, and delivered to the users.

Design and development of environmental information systems

Environmental information science seeks an integrated approach for the design and management of information systems in which a close interaction between the system developers and the environmental experts and decision makers could be provided. The other mission for environmental information science is measuring the effectiveness of these systems, as well. An effective information system as Moxen and McCulloch (1999) insist “contains a range of sources that adequately address the spectrum of environmental issues falling within the scope of the system’s area of concern”. Although measuring effectiveness of environmental information systems is time-consuming and involves many complexities; it could increase the information quality and minimize risks and uncertainties.

Measurement of the users' interests, needs, and behaviors

Environmental information science seeks approaches to investigate whether the presented data fulfill environmental information users' expectations, requirements and needs. It aims to measure opinion and assessment of the users about the relevance and quality of environmental data. Furthermore, it explores techniques and methods to find out whether the environmental data - albeit relevant, precise and with high quality - are interpreted and used properly or not. The concept of “information use” refers to “what people do with information after they have acquired it” (Mutshewa, 2010, p. 213). It involves “engaging mental schemas and emotional responses within a larger social and cultural context” (Choo et al., 2000, p. 14).

Examining the behaviors of environmental individuals is beneficial for understanding the process of environmental information dissemination and use (Moxen and McCulloch, 1999). According to Davenport (1997) information behavior explains how people search for information, use it, modify it, and share it. Studying environmental information behavior is beneficial for finding out how and when environmental information informs environmental decisions and policies (Mutshewa, 2007). Measurement and evaluation of environmental information behavior and linking it to the quality of planning and decision-making is among important functions of environmental information science.

Investigation of the social, economic and policy aspects

Environmental information science has responsibility to conduct research on the social, economic and political aspects of environmental information, its collection, monitoring, measuring and handling. One objective for the investigation of such aspects as Mark (2003) explains is to understand how it can change the efficiency,

effectiveness, equity, and power in society. Social scientists believe there is a need to provide a solid natural science basis for environmental policies by collecting its required information by environmental experts (Mol, 2006). The influences of socio-economic factors on the environmental information systems are also a matter of consideration. Researches should focus on how socio-economic and political difference influences the environmental data accessibility, user education, and the effectiveness of environmental information systems.

Fundamental components and concepts

A number of fundamental components and concepts could be imagined for environmental information science, that all are inter-related: resources, systems, individuals, society, time and scale (Figure 1).

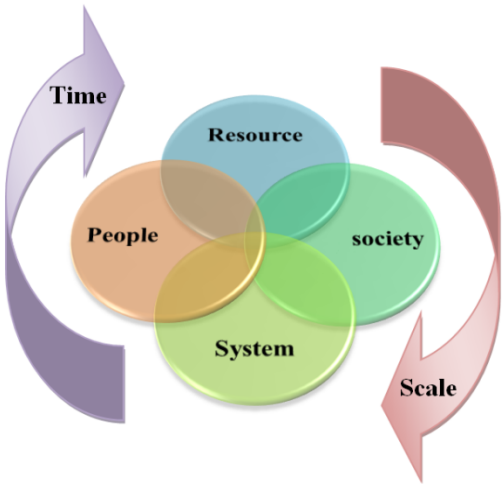

Figure 1: The fundamental components and concepts of environmental information science

Resource

Information resources are essential for getting the information required in the environmental research and planning process. The concept of resource refers to any kind of material containing any identifiable data/information or collection of data/information in any format. Among them, those that best satisfy the environmentalist's and other users' preferences are ones that have the highest information quality (Palsson, 2006). However, other factors are also significant like as the accessibility and the users' skills for using them. The accessibility and usability of information resources as Mutshewa (2007) describes determine whether or not they will be used.

System

Systems are not just software base, but also they could be a collection of integrated strategies, policies, procedures, and techniques working together in a definite structure in order to make information available to the environmental users in all formats from paper to electronic, and for any use from scientific to managerial. Information systems have to fulfill two roles. First, they must cover the appropriate sources of information, and second, they must disseminate the information provided by these sources among the potential users (Moxen and McCulloch, 1999).

People (individual context)

People or individual context is the most important component in environmental information science, because the existence of other components depends on it. People engage in a variety of activities in relation to environmental information such as generation, seeking, processing, and using information (Mutshewa, 2010). Furthermore, they are considered as environmental information sources as Mutshewa indicates: “the environmental experts are the major sources of the information used in the environmental planning process” (2007, p. 433).

Society (social context)

Society is a context for mutual interaction between environmental information and social groups. The social context of environmental information deals with the understanding how society could be affected by environmental information processing. In addition, local communities and social groups are regarded as essential sources of information about their environment, and establishing contacts with them via social networks is considered crucial in facilitating easy access and flow of environmental information (Mutshewa, 2007).

On the other hand, appropriate distribution of and access to environmental information among societies results in awareness on environmental impacts of productions and services. Recent developments in social awareness of environmental problems seem to have effects on the marketing and commercial activities by influencing the purchasing decisions (Erlandsson and Tillman, 2009).

Time

Time and temporal dimensions are essential in environmental information research because environmental phenomena occur with different rates and over different periods of time. Furthermore, the results of many researches on environmental modeling, planning and monitoring may vary by time. On the other hand, diversity of environmental information is valuable at a certain time, and many of environmental decisions are being made under time constraints. Timely

environmental information in the process of decision-making particularly those related to environmental degradation, damages and hazards is crucial for minimizing uncertainty and reducing risks.

Scale

Although environmental information science supports both the small-scale and large-scale studies, its multidisciplinary nature in most cases requires addressing broad scale and long-term questions. Due to the expanding scope of environmental sciences, developers of environmental information systems should address complex and divers problems. As a result, one of the significant components of every research on environmental information is to define and/or understand the scope in which it could be carried out. The concept of *scale* in environmental information science is adapted from its implication in physical science, which indicates the size, extent, or characteristic length of a process (Mark, 2003).

Conclusion

In recent years a large number of information science solutions emerged which might be of special interest to environmental scientists. In the times of limited and valuable environmental and natural resources, the efficient management of environmental information - particularly in the context of emerging issues such as climate change, air pollution, and biodiversity conservation - appears to be promising. Environmental information is rapidly growing with vast amounts of data streaming from sensors, generating by information systems and gathered by researchers in the fields and laboratories (Jones and Gries, 2010). In recent decade, new research directions in environmental science and the improved data management technologies have brought numerous solutions for more sophisticated utilization of the created data and information. However, the diversity and complexity of environmental issues are also growing and the problem of dealing with this huge and diverse amount of information it is still a complicated task. In addition, many problems that have been solved in the context of pure research needs to be implemented in actual sense. For example, several models for information seeking behavior have been suggested in the literature; some have special relevance to environmental information management, but majority of them were not applied for problem solving in a real sense.

Environmental information as a field of inquiry and the extent to which it will be recognized as a science (and not just as a set of systems) could have significant contribution to the future of environmental information management. To achieve this there is a growing responsibility for scientists, information professionals and academic librarians who are working in this field, to identify key scientific questions

of the field and contribute to it through articles and key writings about its methodology, philosophy and foundations.

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