Lorenz M. Hilty (2014): History and Definition of Environmental Informatics. In: Umweltinformatik – Einblick in drei Jahrzehnte der Entwicklung einer Wissenschaftsdisziplin. Edited by: Volker Wohlgemuth, Kristina Voigt, Werner Pillmann. pp. 13-19. Shaker Verlag, ISBN 978-3-8440-2688-7

History and Definition of Environmental Informatics

Lorenz M. Hilty

University of Zurich
Department of Informatics
Binzmuehlestr. 14
CH-8050 Zurich
hilty@ifi.uzh.ch

Abstract: Environmental Informatics has emerged as a research field in the 1990ies and is connected with the name and the work of Bernd Page. This article gives an overview of the history of the research field, from early ideas to an integrative methodology, showing how Environmental Informatics as a mediating discipline has developed over time in the context of changing technologies and environmental challenges.

1 Introduction

The application of information technology to solve environmental problems started already in the 1950s with the first numerical models used for water management, at that time executed on mainframe computers. Applications for air quality monitoring, atmospheric dispersion models, socio-economic models, environmental planning and similar activities followed, calling for a systematic interdisciplinary methodology. This field of study, later called “Environmental Informatics”, emerged in the eary 1990ies and is connected with the name and the work of Bernd Page. This article shows how this field has developed over time in the context of changing technologies and environmental challenges.

2 Early History

Environmental Informatics has many roots. One of them can be found in the proceedings of the fourth Annual Symposium of the American Society of Cybernetics, held in Washington D. C., United States of America, in 1970 (published in 1972). The conference theme was "Management of Ecological Systems", the proceedings volume was titled "Cybernetics, Artificial Intelligence, and Ecology" (Robinson & Knight 1972). In his contribution, S. F. Galler frames the problem as follows:

> „Knowledge acquisition is the answer to the ecological crisis! As always, this is contemporary society's almost reflexive solution to any problem [..] Without a means of transferring and transducing knowledge from the discoverer to the user, from the scientist and scholar to the technologist and the decision maker [...], we are left with magic incantations instead of therapeutic prescriptions [...] it seems to me that the knowledge transfer problem [...] offers model makers, system analysts, and those concerned with developing informational feedbacks some rather interesting opportunities to help correcting environmental maladies." (Galler 1972)

This is a surprisingly early anticipation of ideas that have later been realized in environmental information systems and, more recently, as "persuasive systems". In another contribution, F. F. Gorschboth sketches the vision of an automated air quality control system (Figure 1).

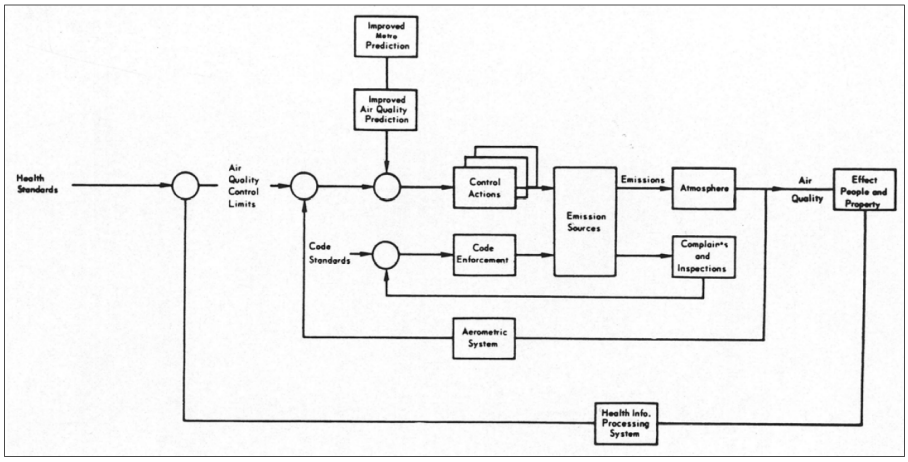

Figure 1: Gorschboth's vision of an air quality control system (Gorschboth 1972).

1.	1967	Purposive Systems
2.	1968	Management of Large Systems
3.	1969	Conflict Resolution
4.	1970	**Management of Ecological Systems**

Table 1: Themes of the first four annual symposia of the American Society of Cybernetics

Table 1 lists the four themes of the first four annual symposia of the American Society of Cybernetics. The fact that the fourth conference was devoted to the

"Management of Ecological Systems" shows both the relevance that the cybernetics community of that time attributed to ecological issues and how they perceived the role of their discipline in this field: as a place of systems thinking that integrates knowledge and technologies across the traditional disciplinary boundaries. This role has later been taken over by informatics.

Another root of Environmental Informatics can be found in Environmental Science, where computer applications for environmental monitoring and control, administrative functions, systems analysis and decision support for policy-makers were developed. Probably the first textbook in this field was published in 1975 under the title "Computer Techniques in Environmental Science" (Ouellette et al.1975).

3 Environmental Information Processing

Before the term "Environmental Informatics" was coined in the 1990s, the name "Environmental Information Processing" was used with a similar meaning. For example, the American Meteorological Society holds an annual conference called "Environmental Information Processing Technologies" which started already in 1984. The name has been kept until this year, when the 30th conference will be held. This conference solicitates "papers that demonstrate successes and advances in interactive computing tools, technologies and observing systems, data management and communication related to advances in observations, modeling, new technologies and media, cyber infrastructure and applications that address issues of extreme climate and weather at varied scales." (AMS 2014).

Radermacher, Riekert, Page and Hilty describe the aim of "Environmental Information Processing" in a paper presented at the 1994 IFIP World Computer Congress held in Hamburg, Germany, as follows:

> "[T]he design of information processing systems for the appropriate utilization of environmental data is a big challenge for computer scientists and other interested parties. The existing solutions often suffer from a narrowed, unidisciplinary view of the problem scope. These solutions fail if additional requirements are introduced, such as interoperability with other environmental information systems and adaptability to future system environments or application scenarios. Another requirement, which has not yet been adequately covered, concerns the transformation of results into reports or other public communication formats which necessitates a strong integration with the domain of multimedia and desktop publishing. Moreover, a major obstacle on the way towards generalizable solutions is the nature of the environmental data which are sometimes very large, very complex, and which require non-standard data structures and processing methods in most cases. Finally, an even bigger problem may be the fact that many politicians, and also scientists, in this field do not yet fully understand the central importance of the proper incorporation of computer science know-how into this framework." (Radermacher et al. 1994)

The term "environmental information system" occurring above reflects the fact that in the early 1990s, public authorities in many countries were building large

information systems to support their tasks in executing environmental regulation, such as environmental monitoring, protection, and planning. Environmental information systems developed in parallel to business information systems, but in a small niche where not monetary flows and capital stocks, but flows of matter and energy, concentrations of pollutants and environmental regulations were in the focus. In 1998, O. Günther defined "Environmental information systems (EIS)" as information systems "concerned with the management of data about the soil, the water, the air, and the species in the world around us." (Günther 1998)
Five years later, an overview on the development of environmental information systems in Germany is published by B. Page and K. Voigt (Page & Voigt 2003).

4 Environmental Informatics as Discipline

The first book with the title "Environmental Informatics" was edited by N. Avouris and B. Page in 1995 (Avouris & Page 1995). Environmental Informatics is described on page 1 of the as "A new discipline […] which combines computer science topics such as data base systems, geographic information systems, modeling and simulation, computer graphics, user interface design, knowledge processing, and neural networks, with respect to their application to environmental problems." (Hilty et al. 1995, 1). Some of the contributions to this multi-authored volume were based on their German-language predecessors published by B. Page and the author in "Umweltinformatik", a book that first appeared in 1994 and in its second edition in 1995 (Page & Hilty 1995).
In a later publication, B. Page and V. Wohlgemuth define Environmental Informatics as a "subdiscipline of Applied Informatics dealing with methods, techniques and tools of Computer Science for analyzing, supporting and setting up those information processing procedures which are contributing to the investigation, removal, avoidance and minimization of environmental burden and damages" (Page & Wohlgemuth 2010, 697),[1] which is again based on Page & Hilty (1995). Emphasis is put on the mediating role of this discipline, which "analyses real-world problems in a given environmental domain and defines requirements on information processing. On the other hand, it introduces the problem solving potential of Informatics methodology and tools into the environmental field" (Page & Wohlgemuth 2010, 697, based on Page & Hilty 1995).
Since its emergence in the 1990s, the focus of Environmental Informatics has shifted. The boundaries of the systems described by the data and models of Environmental Informatics shifted expanded into the technosphere: the man-made processes causing energy consumption and emissions came more and more into the focus, in addition to the flow of substances through environmental compartments.

[1] To properly understand this definition, one has to account for the fact that in German-speaking countries, "Informatik" refers to a discipline which has an applied part and other (theoretical or technical) parts. The former is usually subsumed under "Information Systems" in English, and the latter under "Computer Science".

The focus shifted from effects to causes, from environmental impacts to the processes that can be changed to minimize them.
For this reason, methods of discrete-event simulation for modelling the dynamics of industrial production processes had to be integrated with approaches to Material Flow Analysis (MFA) and for describing material and energy flows. By this integration of paradigms (e.g., Page & Wohlgemuth 2010, Joschko et al. 2014), B. Page and his students have created an approach to Environmental Informatics that is unique and has a great potential to contribute to the solution of environmental problems.

5 The EnviroInfo Conference Series

Probably the most visible outcome of the pioneering work of B. Page is the establishment of the EnviroInfo conference series, which he started together with A. Jaeschke from the Nuclear Research Center Karlsruhe (today: Karlsruhe Institute of Technology, KIT) in 1986. The proceedings of this first conference were published in 1987 (Jaeschke & Page 1987).
During the first couple of years, the conference was held in German under the title "Informatikanwendungen im Umweltbereich" ("Applications of Informatics in the Environmental Sector"). It has been gradually internationalized and was renamed to "EnviroInfo" (as an abbreviation of "Environmental Informatics") in 2002. B. Page hosted the 1994 and 2013 conferences in Hamburg. The development of the conference series has also been shaped in decisive phases by W. Pillmann, International Society for Environmental Protection (ISEP), who hosted the 1990 and 2002 conferences in Vienna. Today, EnviroInfo is the only international conference in this field which can look back on a tradition of almost three decades.

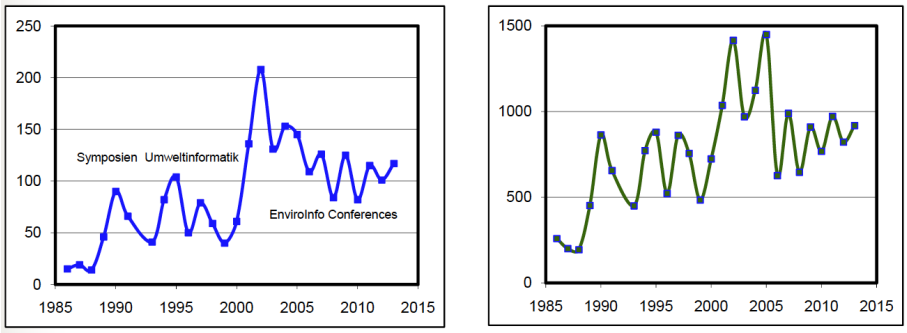

Figure 2: Numbers of papers (left) and pages (right) in EnviroInfo proceedings from 1986 to 2013 (Pillmann 2013)

An overview of the conferences can be accessed at the EnviroInfo website (EnviroInfo, n.d.). Figure 2 shows how the published output of the conference has developed over the years.

6 Conclusion and Outlook

Environmental Informatics can be defined as a mediating discipline that analyses real-world problems in a given environmental domain and defines requirements and methods to construct the information systems needed to solve that problems. Environmental Informatics uses methods from the fields of Information Systems and Computer Science to contribute to the investigation, avoidance and minimization of environmental burden and damages. The problem-solving capacity of Environmental Informatics comes from the integration of methods (such as discrete-event simulation and material flow analysis) which is only possible from an overarching perspective combine with sound technical knowledge. Environmental Informatics would not exist in this form without the work of Bernd Page and his continuing ability to inspire and encourage young researchers to work at the interface of environmental science and informatics.

Literature

AMS – American Metereological Society (2014): 30th Conference on Environmental Information Processing Technologies – Call for Papers. http://annual.ametsoc.org/2014/index.cfm/programs-and-events/conferences-and-symposia/30th-conference-on-environmental-information-processing-technologies/ [Accessed March 2, 2014].

Avouris, N., Page, B. (eds.) (1995): Environmental Informatics – Methodology and Applications of Environmental Information Processing. Dordrecht: Kluwer Academic Publishers.

EnviroInfo (n.d.): Environmental Informatics – International Conference on Informatics for Environmental Protection. http://www.enviroinfo.eu/de/publication/conference [Accessed March 2, 2014].

Galler, S. R. (1972): The Knowledge-Transfer Problem and its Contribution to the Environmental Crisis. In: Robinson, H. W., Knight, D. E. (eds.) (1972): Cybernetics, Artificial Intelligence, and Ecology – Proceedings of the Fourth Annual Symposium of the American Society of Cybernetics. New York: Spartan Books, 283-290.

Gorschboth, F. F. (1972): Environmation. In: Robinson, H. W., Knight, D. E. (eds.) (1972): Cybernetics, Artificial Intelligence, and Ecology – Proceedings of the Fourth Annual Symposium of the American Society of Cybernetics. New York: Spartan Books, 291-302.

Günther, O. (1998): Environmental Information Systems. Berlin Heidelberg: Springer.

Hilty, L. M., Page, B., Radermacher, F. J., Riekert, W. F. (1995): Environmental Informatics as a New Discipline of Applied Computer Science. In: Avouris, N., Page, B. (eds.): Environmental Informatics – Methodology and Applications of Environmental Information Processing. Dordrecht: Kluwer Academic Publishers, 1-11.

Jaeschke, A., Page, B. (Hrsg.) (1987): Informatikanwendungen im Umweltbereich. Karlsruhe: Kernforschungszentrum Karlsruhe (KfK-Berichte 4223).

Joschko, P., Widok, A., Appel, S., Greiner, S., Albers, H., Page, B., (2014): Modeling and Simulation of Offshore Wind Farm O&M Processes. Environmental Impact Assessment Review (in press).

Ouellette, R. P., Greeley, R. S., Overbey II, J. W. (1975): Computer Techniques in Environmental Science. New York: Petrocelli/Charter.

Page, B., Hilty, L. M. (Hrsg.) (1995): Umweltinformatik – Informatikmethoden für Umweltschutz und Umweltforschung. 2. Auflage, München: Oldenbourg.

Page, B., Voigt, K. (2003): Recent history and development of environmental information systems and databases in Germany. Online Information Review, 27 (1), 37-50.

Page, B., Wohlgemuth, V. (2010): Advances in Environmental Informatics: Integration of Discrete Event Simulation Methodology with ecological Material Flow Analysis for Modelling eco-efficient Systems.

Pillmann, W., Geiger, W., Isenmann, R. (2006): Informatics for Environmental Protection, Sustainable Development, and Risk Management: 20 Years Technical Committee on Environmental Informatics. In: Tochtermann, K., Scharl, A. (eds.): EnviroInfo 2006: Managing Environmental Knowledge, Shaker Verlag 2006, ISBN: 978-3-8322-5321-9, 1-14.

Pillmann, W. (2013): Umweltinformatik für eine Nachhaltige Entwicklung. In: Horbach, M. (Hrsg.): Proceedings "Informatik 2013 – Informatik angepasst an Mensch und Umwelt" 16.-20.9.2013, Koblenz. ISBN 978-3-88579-614-5, ISSN 1617-5468, 1005-1012.

Radermacher, F.-J., Riekert, W.-F., Page, B., Hilty, L. M. (1994): Trends in Environmental Information Processing. IFIP Transactions A: Computer Science and Technology (A-52) 1994, 597-604.

Robinson, H. W., Knight, D. E. (eds.) (1972): Cybernetics, Artificial Intelligence, and Ecology – Proceedings of the Fourth Annual Symposium of the American Society of Cybernetics. New York: Spartan Books.