Environmental Indicators

Robert H. Armon • Osmo Hänninen
Editors

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Springer

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An indicator is like a lighthouse, if we don't pay attention we'll end up crashing on the rocks.

To my current grandchildren Yahli, Ivri and Ori and to those to be born in a cleaner world! And also in the memory of my best friends, my late parents Dorothea and Theodor.

Preface

While on sabbatical leave at Kuopio University, Finland, and being involved with the organization called ISEI (International Society of Environmental Indicators), I reached the conclusion that a concentrated effort articulated in a book on various environmental indicators does not exist on the global bookshelf, and this is the time to put one together!

Following discussions with my ISEI colleague Prof. Em. Osmo Hänninen from Finland, a veteran and highly active member of our organization (ISEI), an outlook list was composed, which was intended to be covered later by various international authors (known as experts in their field). Now, in retrospect, we should say that it was not an easy task, as we had to decide which subjects to cover and which to leave for alternative future opportunities. When the subject list had been consolidated, it was communicated to various international scientists, and, following their approval, the book "assemblage" was on its way. I do recall today that in a phone conversation with Dr. Paul Roos (Editorial Director of Environmental Sciences, Springer Dordrecht), besides expressing his interest, he told me that he thought the proposed project a very ambitious one, basically meaning that our venture would not be an easy task.... As scientists, we are never hindered by difficulties, but rather the contrary is true: they make our work more challenging, and therefore, we attacked the task seriously and stubbornly.

Indeed, after more than a year's work, the present book represents the efforts of 80 authors, expressed in 15 subjects and 58 chapters on a large variety of environmental issues, starting from thermodynamics and ending in health issues! The subjects that are covered were selected based on European and US environmental databases, as the important issues that raise critical environmental concerns had been emphasized along the years by these leading entities.

We are happy to bring this compilation to the reader involved in environmental issues, as well as to those who wish to use it as the first textbook on environmental indicators as such. We as well as our academic colleagues always touch upon the indicator issue in our courses, although merely as related to our own specific professional field. The present book is the first effort to present the most

important indicators together and consolidate a unifying line between the various subjects. We hope that this volume achieves this task well and can be used by many thousands of scientists involved in environmental research.

Haifa
April 2014

Prof. Robert H. Armon, Faculty of Civil and Environmental Engineering, Technion (Israel Institute of Technology), Department of Environmental, Water and Agricultural Engineering, Haifa 32000, Israel. Board Member of IWA Specialist Group-HRWM (Health-Related Water Microbiology).

Kuopio
April 2014

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And finally to all authors that contributed to this book with their intellectual knowledge, effort and time.

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Introduction

Perhaps the finest analogy to the role of indicators can be found in the physician's preliminary examination of a patient. Any respectful physician will start his or her diagnosis of a patient with simple and fast tests that are easy to perform, e.g., temperature, blood pressure, physical contact to detect pain, etc., and only later will apply the more sophisticated tests, such as CT, MRI, or the simpler X-ray radiography, in order to reach a final diagnosis. We should bear in mind this analogy when handling environmental indicators.

Environmental indicators are simple events that let us know what is happening in different surrounding environments. Because of its complexity, environmental measurement should be performed using a less expensive and cumbersome approach involving a large variety of indicators. For example, to measure the presence of a pathogen in potable water in order to ensure the safety of a water supply, a large battery of expensive materials and methods are required that in some cases are useless and in others practically and economically almost impossible to accomplish! In most cases, those pathogens are found in low numbers, therefore requiring a concentration step, which will increase the economic burden (especially since thousands of such tests are required annually) to the extent of leading to economic bankruptcy! On the other hand, for health people, what is the epidemiological significance of one viral/bacterial particle in 1,000 L? Consequently, the indicator system makes our lives easier and is a matter of choice, both economically and scientifically. Below, we present two historical examples of "classical indicators" and their introduction and use.

Historically, microbiological indicators of the sanitary quality of water were introduced at the end of the nineteenth century. In 1880, Von Fritsch described *Klebsiella pneumonia* and *Klebsiella rhinoscleromatis* as characteristic human fecal bacteria, and in 1885 Percy and Grace Frankland introduced the first routine bacteriological examination of London's water, using Robert Koch's solid gelatin media for bacterial enumeration. The same Frankland, in 1891, came up with the idea that sewage microorganisms should be characterized in order to give warning of a potential sanitary hazard. In 1885, Escherich described *Bacillus coli*

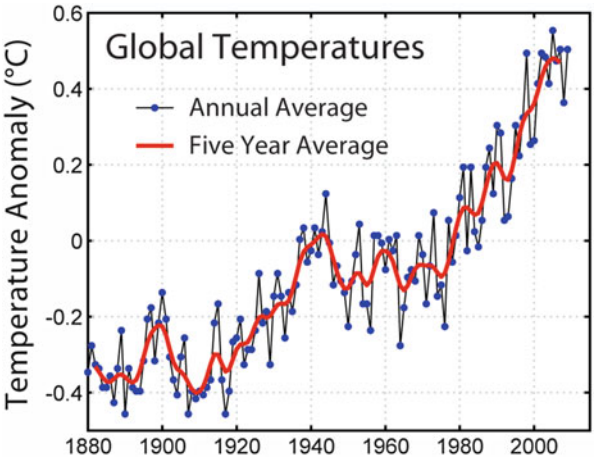

Fig. 1 An example of an environmental indicator: Trend in global temperature anomalies of the last 150 years as an indicator of climate change (Source: National Aeronautics and Space Administration, Goddard Institute for Space Studies (http://data.giss.nasa.gov/gistemp/graphs_v3/); Hansen et al. 2006)

(now called *Escherichia coli* in his memory) as a typical bacterium originating from the feces of breast-fed infants. Then, starting at the beginning of the last century (1900 and on), *Bacillus coli* was used as an indicator in the UK of potential water contamination with fecal material. To make a long story short, specific human fecal bacteria became the standard indicators of potable water safety! Together with the introduction of chlorination, waterborne diseases were significantly reduced worldwide. Today, those bacteria are used as the common indicators of water pollution, in spite of their many drawbacks.

Another example of an important indicator, which marked the way to apprehending climate change, is the temperature rise over time as an indicator of global warming (Fig. 1)! Temperature measurements are easy to perform and have been conducted for more than 100 years. Therefore, using their anomalies frequency as an indicator, it can be concluded that there is an essential shift in global temperatures.

Both examples show the use of simple, fast, and cost-effective parameters that have a real potential to indicate with a certain percentage of accuracy that our environment is polluted or is facing a problem!

This book presents many such indicators covering a large area of environmental issues that affect the human population globally. It is our pleasure to bring to the attentive environmentalist reader a large panel of indicators that are in use, or whose potential as such is proposed, to achieve a more livable and cleaner planet (Maher 2011).

The editors would like to thank all contributors and the Springer publishing house, especially Dr. Paul Roos for his support and encouragement and Ms. Betty van Herk for her editorial support. We would like to thank the authors' families for their equability and for understanding the value of our contribution, in spite of long hours and days in the office.

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Maher B (2011) The new rules: a funny look at how everybody but me has their head up their ass. New rule: oil companies must stop with the advertisements implying they're friends of the environment. 'At Exxon Mobil, we care about a thriving wildlife.' Please – the only thing an oil executive has in common with a seagull is they'd both steal French fries from a baby. Blue Rider Press

The International Society of Environmental Indicators: Historical Overview

The International Society of Environmental Indicators (ISEI) is an international network of scholars who support and promote the development and use of biological, chemical and physical environmental indicators in environmental assessments and environmental management. Environmental indicators are critical components of monitoring efforts worldwide, and because many environmental indicators are relatively inexpensive to monitor, ISEI makes efforts to work with scientists in developing countries to enable them to better integrate environmental indicators in their environmental assessment and monitoring efforts. This overview describes its formation and development.

The ISEI traces its origin to a series of sessions on bioindicators, or biomarkers, organized by myself and Jim Newman at the Annual International Conference on Contaminated Soils, Sediments and Water held at the University of Massachusetts, Amherst in 2002–2005. Abstracts from the inaugural session are available at: http://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1001&context=soils_conf_abstracts. In 2003, we published a paper on *Bioindicators – Essential tools for realistic site assessment and remediation cost control* in the March/April issue of The Association for Environmental Health & Sciences (AEHS) magazine, *Soil Sediment & Water*. It was in Amherst during this period when several new journals were being launched by Amherst Scientific Publishers, an affiliate of AEHS. I was having lunch with Paul Kostecki, the co-founder of AEHS, and suggested that there was a need for a journal on environmental bioindicators and that AEHS should consider adding such a journal to their portfolio. Paul responded with, "Why don't you do it?" This was not something I had contemplated before and it took a couple weeks to get used to the idea. I contacted Jim Newman to see if he would be interested in partnering with me on the venture and found him to be enthusiastic. I then called a contact at Taylor & Francis Group, LLC (T&F). A short time later, Jim and I were invited to meet with the publishing staff of T&F at their corporate offices in Philadelphia. We were advised that the chances of such a journal being a success would be greatly enhanced if we were to form a scientific society to support it.

The first meeting of the new International Society of Environmental Bioindicators was held in concert with the Thirteenth International Conference on Environmental Bioindicators of the International Union of Biological Scientists (IUBS), International Commission on Bioindicators at the Vila Porthemaka Praha, Czech Republic, 6–10 June 2005. The formation of the new society was proposed and agreed to by the participants. (The name of the new society was formally changed to the International Society of Environmental Indicators [ISEI] in 2009 to reflect the broader scope of the interests of its members.)

The inaugural issue of a new international journal, *Environmental Bioindicators*, was published by T&F in the first quarter of 2006 in print and online (ISSN 1555–5275, and 1555–5267, respectively). The print version of the journal continued to be published quarterly through October-December 2009. A brief history of the changes and milestones in the structure of the journal and in the development of the society was reported in an editorial at the completion of its first 4 years of publication (Zillioux EJ, 2009, *Environmental Bioindicators* [EBI] to *Environmental Indicators* [EI] and other Developments: the evolution of a journal. Vol. 4, pp. 283–285). Beginning with volume 5 in 2010, *Environmental Indicators* became a stand-alone on-line open-access journal. Complete contents of all issues of both print and subsequent on-line volumes are accessible at www.environmentalindicators.net.

Following the Prague conference, the ISEBI and subsequent ISEI Conferences continued on an annual basis from 2005 through 2011. At the 2011 conference it was decided to hold future conferences on a biennial basis. The first biennial conference was held in 2013 and the next is planned for 2015. All ISEI conferences are listed with details on Table 1; in addition, a related and linked conference, held in Moscow in 2013, is also listed.

Table 1 Conferences sponsored by ISEI, 2005–2015

Conference		Theme	Location & sponsoring institute
	21st International Conference on Environmental Indicators 9th ISEI International Conference 2–5 August 2015	Water Quality Indicators	Windsor, Canada – University of Windsor and the Agriculture and Agri-Food Canada
	20th International Conference on Environmental Indicators 8th ISEI International Conference 16–19 September 2013	Monitoring Indicators to Inform and Diagnose Environmental Hazards and their Impacts	Trier, Germany – Trier University
	An ISEI-Related and Linked Conference 4–6 February 2013	Bioindication in the Ecological Assessment of Soils and Related Habitats	Moscow, Russian Federation – Moscow State University

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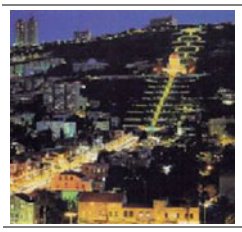	19th International Conference on Environmental Indicators 7th ISEI Annual Meeting 11–14 September 2011	Environmental Indicators with a Global View	Haifa, Israel – *Technion-Israel Institute of Technology*
	18th International Conference on Environmental Indicators 6th ISEI Annual Meeting 13–16 September 2010	Polar & Marine Environmental Changes and Pollutants & Other Anthropogenic Impacts	Hefei, China – University of Science and Technology of China
	17th International Conference on Environmental Indicators 5th ISEI Annual Meeting 18–20 May 2009	Global Indicators	Moscow, Russian Federation – Moscow State University
	16th International Conference on Environmental Indicators 4th ISEI Annual Meeting 11–14 November 2008	Management Metrics	Orlando, Florida, USA – Environmental Indicators Foundation, LLC
	15th International Conference on Environmental Indicators 3rd ISEI Annual Meeting 7–9 June 2007	Bioindicators for Environmental Management	Hong Kong, SAR, China – City University of Hong Kong
	14th International Conference on Environmental Indicators 2nd ISEI Annual Meeting 24–26 April 2006	Indicators of Performance and Trends	Linthicum Heights, Maryland – Maritime Institute
	13th International Conference on Environmental Indicators 1st ISEI Annual Meeting 6–10 June 2005	Large-scale Biomonitoring	Prague, Czech Republic – University of South Bohemia

ISEI is governed by an elected Board currently headed by: President: Diane Henshel, Ph.D., Indiana University, Bloomington, IN, USA, dhenshel@indiana.edu, and Vice President: Zhi-Qing (ZQ) Lin, Ph.D., Southern Illinois University, Edwardsville, IL, USA, zhlin@siue.edu. Other Officials of the Society include: Secretary: Nancy Denslow, Ph.D., University of Florida, Gainesville, FL, USA, ndenslow@ufl.edu; Editor-in-Chief: Nicholas V.C. Ralston, Ph.D., University of North Dakota, Grand Forks, ND, USA, nralston@undeerc.org; Treasurer: Edward Zillioux, Ph.D., Environmental Indicators Foundation LLC, Fort Pierce, FL, USA, zillioux@bioindicators.org; and Board Members: Robert Armon, Ph.D., Technion, Haifa, Israel; Jill Jenkins, Ph.D., Geological Survey, Lafayette, LA, USA; Roland Klein, Ph.D., Trier University, Trier, Germany; James Newman, Ph.D., Normandeau Associates, Inc., Gainesville, FL, USA; and Carla Ralston, Ph.D., University of North Dakota, Grand Forks, ND, USA.

The ISEI journal and society website is in the process of being upgraded to make it more efficient to use and easier to access and to submit papers. The Board is currently conducting a Membership Drive to strengthen the vitality of ISEI and to carry forward the critical mission of this society:

Mission Statement and Objective

The International Society of Environmental Indicators (ISEI) and its journal, *Environmental Indicators* (JEI), seeks to explore the scientific bases and uses of indicators (biological, chemical, physical) and biomarkers as they relate directly to specific measurable effects in ecological and human populations from environmental exposures. Emphasis is placed on the application of molecular to landscape level indicators as tools to help in understanding the probability that the presence of a contaminant(s) or other disturbances in the ambient environment that may produce an adverse effect in exposed receptors or populations, the degree of harm that may be indicated, and the integration of these data to characterize environmental health. Environmental indicators range from molecular and genetic indicators to landscape-level indictors reflecting the conditions of the human and ecological environments.

It is the objective of the Society to provide an empirically-derived foundation in the use of indicators to help define environmental health and requisite protection or restoration needs, and from which responsible action, including informed and cost-effective regulatory endpoints, can be developed.

The ISEI membership application (which is also available on the Society website: http://www.environmentalindicators.net/) is attached for the convenience of prospective renewal and new membership applicants. Please copy the application and follow submittal instructions. Thank you.

Acknowledgements Thanks are due to Drs. Diane Henshel, Nicholas Ralston, and Zhi-Qing (ZQ) Lin for their reviews and helpful suggestions which have substantially improved this chapter.

Fort Pierce, FL, USA Edward J. Zillioux

2014–2015 ISEI Membership Application

International Society of Environmental Indicators (ISEI) http://www.environmentalindicators.net.

Year of Renewal or New Member Application: _____

(Memberships are accepted on a calendar-year basis only; dues include subscription to the on-line journal, free manuscript submissions, and conference registration fee discount)

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❒ Regular Membership: US**$100.00** per year

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* "Developing Countries" are those categorized as "Low-Income," "Lower-Middle-Income," and "Upper-Middle-Income" by the World Bank; see http://go.worldbank.org/D7SN0B8YU0

❒ Special Membership Rate for Students: US**$15.00** per year (a valid student ID required)

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Amount (USD): $_____

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PayPal: Payments for membership can be processed through PayPal. **Option 1:** Interested individuals who have a PayPal account can send payments to

zillioux@bioindicators.org. **Option 2:** Interested Individuals who do not have a PayPal account, should send an email to **zillioux@bioindicators.org** requesting payment through PayPal. I will forward your request and PayPal will contact you and ask for your credit card information. Your card information is protected by PayPal.

Check or money order: Make payable to "Environmental Indicators Foundation, LLC" in US funds. Send to ISEI, 207 Orange Avenue, Ste. G, Fort Pierce, Florida, 34950, USA

Member Information:

Name: _____
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Print and complete this form and mail to: Edward J. Zillioux, Treasurer and ISEI Business Manager, 207 Orange Avenue, Ste. G, Fort Pierce, FL 34950, USA, or send a scanned copy by email to: **zillioux@bioindicators.org**.