Environmental Literacy in Science and Society: From Knowledge to Decisions

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1 author:

Roland W. Scholz
Danube University Krems, Faculty of Economics and Globalization
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From Knowledge to Decisions

Roland W. Scholz

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Overview: roadmap to environmental literacy

Natural and social environments are constantly adapting to changing demands from human systems. This particularly holds true as we see increasing impacts on the natural environment and resources from human systems. A key question is whether societies and their subunits have sufficient knowledge about the structure, dynamics, limits, and potential of human–environmental systems to function and evolve in a sustainable manner. And what role can science take to help in this venture? We deal with these fundamental problems under the heading of environmental literacy. "Environmental literacy" means the capacity to perceive, appropriately interpret, and value the specific state, dynamics, and potential of the environmental system, as well as to take appropriate action to maintain, restore, or improve these states. This book elaborates what knowledge and capabilities should be available in science and society to develop suitable strategies for coping with critical interactions of human systems with environmental systems. This should ultimately help to avoid the unintended and unpleasant environmental rebound effects of human action, and allow us to cope with conflicting interests which may hamper sustainable transitions.

Given these societal and scientific challenges, this book is a source book for those interested in the following questions related to environmental literacy:

- Why and when was the concept of the environment developed?
- Do we have to redefine the environment when facing that most processes in the material–biophysical layer of the Earth are affected by human action?
- How do various scientific disciplines deal with the interrelationship between human systems and the environment?
- How can we distinguish the material–biophysical environment, which includes the built environment, from the social-epistemic environment, which is historically and culturally shaped?
- When, why, and in what context are human systems concerned about the state, dynamics, potential, and negative impacts of environmental states and resources?
- What drives human systems (such as individuals, groups, companies, and societies) to exploit, protect, or sustainably cope with the environment?
- How can conflicts and dilemmas between individual and societal environmental behavior (i.e. interferences between the micro and the macro levels of human systems) be explained?
- What constitutes sound environmental literacy, sustainability learning, and sustainable behavior?

Preparing for map reading

Part I of this book consists of three chapters that illuminate why environmental literacy is of interest and what it is. We define different types of human and environmental systems and explain how these systems relate and interact. We further introduce some tools (i.e. epistemological assumptions) that are helpful to better understand what the reader will encounter in the different stages of the journey.

From the origins to the future of environmental literacy

To read our answers to the questions above, the reader can continue in Parts II–VI on a journey from the history to the future of environmental literacy in science and society. We introduce epistemological assumptions as prerequisites for coping better with the challenges of examining environmental literacy.

After this initial descent into the origins of environmental literacy, we wander through a handful of scientific disciplines. These stages of our journey will not always be the most convenient ones. Depending on the

disciplinary background of the reader, he or she will sometimes have to row upstream. We start with biology, where we learn about the origins of human knowledge about organismic environments and about how societies can successfully conserve and develop this knowledge. We also explore those biological principles that are of special interest for mastering sustainable development. We make an excursion to the frontline of research on microstructures, such as the cell, and the immune system. Here we can discover how important the environment is for these systems and how they process environmental information. A comparative view of large-scale biological systems reveals that they are strongly affected by human systems and miss the essential self-regulating, homeostatic properties of microstructures.

We then look to psychology to gain an understanding of the biophysical, social, and cognitive foundations of human perception, decisions, and behavior. The sections on psychology also provide insight into the drivers of individuals and small groups when interacting with the material and social environment.

In the next stage, sociology, we focus on theories that consider the natural environment and technology as significant factors of societal development. Just as with psychology, we meet approaches that provide insights into the drivers of societies in human–environment interaction and that explain why and when environmental issues raise concern. However, we will learn that we can find a material–biophysical layer in many but not all sociological approaches. In some they are hidden, in some they do not exist.

The last stage in looking at social sciences is economics. Following our own curiosity we explore the roles that material, biophysical, land and other resources play from the view of classical and neoclassical economics, and the types of goods that are dealt with in this discipline. In new terrains of economics, we will see that economists make highly controversial assumptions about how one should deal with natural resources and the material–biophysical environment. Some seem to be reckless, whereas others seem overly troubled about their future markets and companies. We also learn that many ideas from other sciences have invaded the new subfields of economics that deal with the environment.

Next, we look at industrial ecology, a small but steadily growing discipline investigating how companies, industrial branches, and trade can reinvent themselves to reduce environmental impacts resulting from production, business, and services. Here we encounter some engineering methods that allow the assessment of manmade environmental impacts. But we also look at some special sites, such as eco-industry parks, from which we can learn to better cope with material flow. What is more, we see how industrial ecology offers broad, long-term perspectives and strategies for the future of environmental literacy. This offers a global view that highlights the fundamental changes that the landscape of human–environment interaction has undergone in the past and also the new structures and components that this landscape might exhibit in the future.

Our journey could have taken another route with different stops. Besides biology, we could also have looked, for instance, at geology, and, instead of industrial ecology, at civil and environmental engineering. Naturally, other disciplines, such as geography or anthropology, could deserve their own chapter. However, we think that the selected disciplines allow the demonstration of why and when various types of contributions to environmental literacy emerged in academic disciplines.

The reader might ask why we are not visiting some new, exotic and more exciting domains, such as environmental or sustainability sciences. These two disciplines are the current home base of the author, and scientists from these disciplines are the most likely to use our roadmap to promote environmental literacy. As key question 3 of the Preamble indicates, we explore each discipline both for its unique knowledge and for the value it can bring to investigations that involve more than one discipline. We call this perspective, common to environmental and sustainability sciences work, "disciplined interdisciplinarity."

Provisions for traveling beyond the boundaries of disciplines and sciences

The first part of the journey highlights how many issues from different disciplines are indispensable to cultivate environmental literacy. But knowledge from lone disciplines only takes us partway toward answers to today's environmental problems. In Part VII, this book introduces three new perspectives that are required to take us further.

The first is that today's environmental problems cannot be managed without incorporating analysis of human systems that affect many processes on all levels,

from molecular up to global biogeochemical processes of the material–biophysical environment. This asks for redefinition of the environment and the destination of the journey. We will discuss a new goal for the second stage of the journey, which includes an anthropocenic redefinition of the environment.

Second, environmental literacy requires an integrated view of knowledge about the environment and human–environment interactions. This requires new techniques of making and processing pictures. We will see how "integrated modeling" becomes a vital means of extending environmental literacy and allows a deeper understanding of what we have seen. This will facilitate in taking an *interdisciplinary* view.

Third, we will notice that, in the first stages, disciplinary scientists face limitations in acquiring all the information about the environment. Thus, we, along with these scientists, have to leave our travel route and step into real-world cases to gain valuable additional information from directly talking, interacting, collaborating with, and getting first-hand information from the people and human actors who are directly experiencing, benefiting from, and interacting with the environment. This provides a completely new perspective, which we call *transdisciplinarity*. We will see that the people incorporated in transdisciplinary processes benefit from and appreciate these mutual learning processes.

Extending environmental literacy: the human–environment systems Postulates and the HES framework

After this intermediate stop and reorientation, we explore new territory and the character of the journey changes. It will slightly resemble an excursion into more complex domains. Instead of the environment, human–environment interactions become the object and objective of the journey. It becomes difficult to keep track of our place, to figure out where to go first, and to know what we need to move toward these new destinations. Thus we offer Part VIII as a guidebook that outlines seven Postulates, or assumptions, for investigating human–environment systems (HES). This travel guide consists of seven Postulates, the HES Postulates. The HES Postulates depict the constituents of the HES world, how HES behave, how they can be classified, and of what they are and are not aware. We also examine the drivers of human systems and the conflicts that may exist between individual agents or subunits and superordinate systems. The latter can be communities or societies.

An important point of the guidebook is that we have to conceive HES as coupled, inextricably intertwined, systems. However, the guidebook also explains that we must first have a thorough look at the environment, in particular at the material–biophysical environment if we want to understand what a specific HES looks like, how it evolved and what future development might take place. The HES are explained by a Postulate that describes different types of feedback loops that may be at work in HES.

We will see that the HES Postulates draw on what we have learned when looking at the scientific disciplines in the first part of the journey. Our knowledge of social sciences, for example, will help us to understand the interests and values that underlie the rationale of human systems when interacting with the environment.

Having become familiar with the individual Postulates, we know how the Postulates relate to each other and how they can work together during an investigation of an environmental issue. We put forth this HES framework as a template for transdisciplinary collaboration.

Four cases for demonstrating HES literacy

Equipped with the HES framework, we are prepared to take a closer look at the challenges and threats of human–environment interactions. In Part VIII, we make four excursions, each of them demonstrating the improved environmental literacy gained by working with the HES Postulates.

Trip 1 looks at epidemic and pandemic threats. Using the HES Postulates we learn that the outbreak of pandemics is shaped by more than the mechanisms of viruses and bacteria. The type and severity of pandemics, and the unexpected rebound effects that may result from various pandemic management approaches, ask for an examination of the behavioral, contact, and mobility matrices of human systems. A look at micro and macro structures and their interactions is needed here.

Trip 2 involves an excursion to Switzerland. We scrutinize how transdisciplinary processes involving scientists and key agents, as well as people from the region, are helping government and industry to better adapt to market and environmental constraints. We learn that transdisciplinary processes are

useful to identify robust orientations to find sustainable solutions.

Trip 3 looks at how HES manage basic supply services. The jaunt takes us to Sweden, where we encounter unexpected limits to biofuel resources. Here we see how proper identification of secondary feedback loops is a key feature of sustainability learning.

Lastly, trip 4 provides profound insights into the difficulties that human systems and societies face when making trade-offs and protecting natural resources in the anthropocenically formed environment. The case we look at is the dilemma of establishing a recycling management system for some minerals (i.e. phosphorus) when simultaneously aspiring to eliminate and dispose of material matter (e.g. carcass meal and bones), which includes high concentrations of the said mineral but also dangerous pathogens.

Upon our return from these trips, we check whether the guidebook and the HES framework have served as an effective compass for environmental literacy as we have defined it above. To do this we compare the HES framework with alternative travel guides.

The vision on future environmental literacy

The journey closes in Part IX by identifying key components that may promote environmental literacy ("Sustain–abilities", see Chapter 20.04.1). These are the new fields of environmental and sustainability sciences that cope with inextricably coupled HES. The HES framework, based on disciplined interdisciplinarity, allows a thorough investigation and understanding of complex environmental problems. Transdisciplinarity includes processes which use knowledge from theory and practice to generate socially robust solutions for sustainable development.

How to access the chapter overviews

After the novelist-like overview, the reader can best gain access to the content of the book by reading the sections "What to find in this part" on the front pages of all nine parts and of the 20 chapters. A closer look at the roadmap and its extended legend on pages xxii–xxiii may also help to understand the structure, main subject matters and the storyline of this sourcebook.

Who should use this book?

The overview suggests that this book might be of interest to those who are curious about how the environment interacts with human systems and how human systems, from the individual through groups, organizations, companies, communities and society to the whole human species, can become capable of adequately adjusting and adapting to the continuously changing and increasingly anthropocenically shaped environment.

These primary readers are researchers from the emerging fields of environmental and sustainability sciences who are interested in human-environment interactions or systems. Clearly, it is also relevant to anthropologists, human ecologists, geographers, and environmental planners, or people working in the hyphenized fields of sciences, such as environmental–psychology, -sociology, or -economics. Readers will also no doubt include people from the natural sciences, including ecology and those working with the climate and atmosphere. The book will also be of interest to those working in environmental chemistry and those in different branches of engineering sciences, such as industrial ecology, may learn from the comprehensive, integrative, coupled system perspective which looks at the constraints, feedback loops, and regulatory mechanisms of HES.

Environmental literacy is not only seen from an academic learning perspective but is rather focused here on what we call *societal didactics*. Thus, it should contribute to societal learning about how to cope with environmental challenges and provide access to the rationale of human–environment interactions. Further, this vision and the practice of transdisciplinarity were motivators for writing the book. However, as expressed in the Preamble, establishing a thorough, discipline-grounded interdisciplinary knowledge about HES, which favors transdisciplinary processes that deal with the current and future environmental challenges, is the very vision and mission of this book.

Legend of the roadmap

The concept map shows how the ideas in this book relate. The figures in the concept map come from informational boxes that are sprinkled throughout the book and tell stories from around the world, both historic and contemporary, that illustrate our message.

Our starting point is the question, "Who invented the environment?" Chapter 1 describes how humans' awareness of their impacts on the environment developed and when and why the concept of the environment was invented. Chapter 2 provides a first definition of environmental literacy and introduces the value that transdisciplinarity can bring to how humans address environmental issues. Chapter 3 introduces the concept of environment based on an organismic, cell-based definition of the human individual and the complementarity of material–biophysical and social-epistemic levels of human and environmental systems. Here we describe the basic ontological and epistemological assumptions that underlie our world view and thesis.

To discuss the issue, "What disciplines can and can't tell us," we review contributions to environmental literacy from five academic disciplines – biology, sociology, psychology, economics, and industrial ecology – in Parts II through VI. Taking two chapters to cover each discipline, we review the history of mind for each, examining which aspects of human–environment interactions were of interest during different time periods. We also review key theories from each discipline and prospective future perspectives that can inform environmental literacy.

In Part VII, Chapters 14 and 15 describe the pivotal, integrating function of "managing interfaces to become literate." We examine how knowledge integration and transdisciplinarity help us to decrease the complexity of environmental issues, which warrant an "Anthropocenic redefinition of the environment in a coupled human–environment setting."

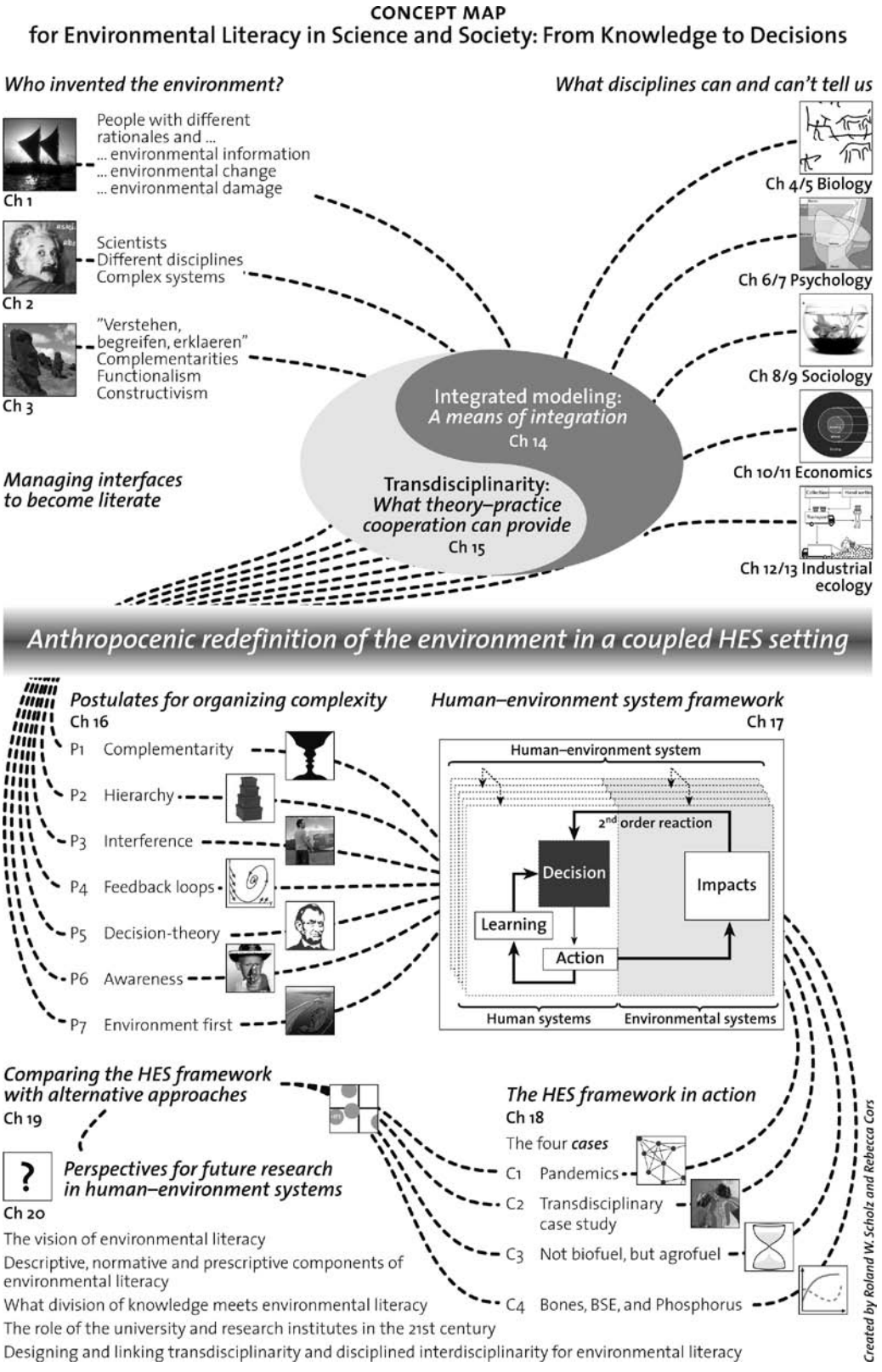
We put forth seven Postulates, P1 to P7, to organize the complexity of today's environmental issues and related research.

The HES framework is a methodological schema for employing the Postulates in an integrated manner when investigating environmental issues.

To give readers a feeling for the HES framework in action, Chapter 18 presents four case studies.

Chapter 19 compares the HES framework with alternative approaches and shows what added value it can provide.

The last chapter presents "Perspectives for future research in human–environment systems," and links the coupled systems and the transdisciplinary perspective (see bottom left of the concept map and key question 3).


CONCEPT MAP
for Environmental Literacy in Science and Society: From Knowledge to Decisions
Who invented the environment?
What disciplines can and can't tell us
People with different rationales and ...
... environmental information
... environmental change
... environmental damage
Ch 1
Scientists
Different disciplines
Complex systems
Ch 2
"Verstehen, begreifen, erklaeren"
Complementarities
Functionalism
Constructivism
Ch 3
Integrated modeling:
A means of integration
Ch 14
Transdisciplinarity:
What theory–practice cooperation can provide
Ch 15
Managing interfaces to become literate
Ch 4/5 Biology
Ch 6/7 Psychology
Ch 8/9 Sociology
Ch 10/11 Economics
Ch 12/13 Industrial ecology
Anthropocenic redefinition of the environment in a coupled HES setting
Postulates for organizing complexity
Ch 16
P1 Complementarity
P2 Hierarchy
P3 Interference
P4 Feedback loops
P5 Decision-theory
P6 Awareness
P7 Environment first
Human–environment system framework
Ch 17
Human–environment system
2nd order reaction
Decision
Impacts
Learning
Action
Human systems
Environmental systems
Comparing the HES framework with alternative approaches
Ch 19
Perspectives for future research in human–environment systems
Ch 20
The vision of environmental literacy
Descriptive, normative and prescriptive components of environmental literacy
What division of knowledge meets environmental literacy
The role of the university and research institutes in the 21st century
Designing and linking transdisciplinarity and disciplined interdisciplinarity for environmental literacy
The HES framework in action
Ch 18
The four cases
C1 Pandemics
C2 Transdisciplinary case study
C3 Not biofuel, but agrofuel
C4 Bones, BSE, and Phosphorus
Created by Roland W. Scholz and Rebecca Cors

This unique book provides a comprehensive review and analysis of environmental literacy within the context of environmental science and sustainable development. Approaching the topic from multiple perspectives, it explores the development of human understanding of the environment and human–environment interactions in the fields of biology, psychology, sociology, economics, and industrial ecology. The discussion emphasizes the importance of knowledge integration and transdisciplinary processes as key strategies for understanding complex human–environment systems (HES).

Roland W. Scholz chairs the Natural and Social Science Interface in the Department of Environmental Sciences at the ETH (Swiss Federal Institute of Technology), Zurich.

"This is a visionary book that comprehensively approaches modern sustainability challenges by recognizing the critical role of integrated human, natural and built domains in the complex systems that characterize the Anthropocene."
Braden Allenby, Arizona State University, USA

"In this brilliant work, Roland Scholz addresses how society may make the 'great transition' toward sustainability in a remarkably open and honest exploration of human-environment systems. He demonstrates that interdisciplinary research is not enough – we need transdisciplinary research to integrate our scientific knowledge in a way that results in sustainable decision making. The book provides a roadmap for managing the earth's biogeochemical cycling in a sustainable way."
Cliff Davidson, Syracuse University, USA

"Developing adequate solutions for human-environmental problems requires both substantive expertise and a deeply interdisciplinary perspective. Anyone who doubts this assertion need spend but a few minutes reading almost any part of Roland W. Scholz's monumental work on Environmental Literacy to have their doubts erased."
M. Granger Morgan, Carnegie Mellon University, USA

"Scholz's book is both a sparkling sourcebook and an advanced textbook for sustainability science. It is also the first successful attempt at producing a convincing theory of coupled human-environment systems."
Ton Schoot Uiterkamp, University of Groningen, The Netherlands

"This book provides an inspiring boost to our own environmental literacy, what it is and how it historically developed… it may well serve as a reference book for various scientists, policy-makers and other key actors who want to improve and reflect on sustainable transitions."
Charles Vlek, University of Groningen, The Netherlands

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