Part I

Invention of the environment: origins, transdisciplinarity, and theory of science perspectives

Key questions (see key questions 1–3 of the Preamble)

What aspects of the key questions are answered in this part?

Q1 How do human systems *represent, store* and *retrieve* information about their environment?

Q2 How can we identify the drivers of human behavior?

Q3 What manmade environmental impacts can/should we change? What rebound effects can emerge from intervening? How can society generate appropriate knowledge and strategies for sustaining the Earth's environments?

What is found in this part

Chapter 1 introduces how environmental awareness emerges, and provides a first tight definition of environmental literacy as a necessary aptitude for human systems to sustain and to adapt to environmental change. We discuss from a historical point of view how the concept of environment was invented and reflect on the role of science in assuring that societies have the proper knowledge to master environmental challenges.

Chapter 2 takes a more differentiated view on what environmental literacy comprises. We show why thorough natural science knowledge is necessary but also why it is not sufficient as what becomes an environmental problem is based on human needs, interests, and values. We reveal that dealing with environmental problems often causes unwanted feedback loops and requires coping with trade-offs and conflicting interests of human systems. Coping with or integrating different interests and perspectives is one of the five types of knowledge integration included in environmental literacy. Another type is the use of different kinds of knowledge. Here we distinguish the experience-based understanding of practitioners, who often work with intuitive coping strategies for environmental challenges, and science-based knowledge, which is a specific type of analytical knowledge. This leads us to transdisciplinarity, which is a specific form of learning and cooperation between different parts of society and academia to meet the complex challenges of society.

Chapter 3 expands the basic ontological and epistemological assumptions underlying this book, which views environmental literacy as a dynamic learning process and offers the human–environment system (HES) framework for examining how humans interact with their environment. The framework is based on a specific definition of human systems that refers to the activities of human individuals which can be assigned to this system. This approach, together with a cell-based definition of human individuals, allows for a cohesive definition of human systems, environmental systems and of the human–environment complementarity.

Part I Invention of the environment

Chapter 1 What knowledge about what environment?

Chapter overview

Humans' concerns about and interactions with the environment, from navigating the seas to managing a farm or operating a nuclear power plant, have emerged from the core need to survive by using environmental information and resources. This chapter explores the emerging awareness of the environment as a prelude to understanding human interactions with the environment. Central to this discussion is environmental literacy – the human aptitude for appropriately reading and using environmental information to use environmental resources properly and to adapt effectively to environmental dynamics. This chapter reveals what knowledge about the environment is relevant, what environmental literacy means, and introduces the drivers and rationales underlying environmental awareness.

1.1 How did environmental awareness emerge?

A few decades ago environmental issues surfaced, for the first time, as important public concerns. In this book we elaborate on how environmental awareness arose in science and society, and how this awareness shifted from simply perceiving the environment to interacting with and influencing it in a world with roughly seven billion people. Long before the time of Christ, there was already considerable environmental impact from large cities in Mesopotamia and elsewhere, such as Ur, Nineveh or Carthage, with populations up to 700 000. Most theories on the decline of the Maya and other ancient societies include ecological hypotheses such as environmental disasters, climate change or overpopulation. For example, suspicions that the spread of diseases such as plague and cholera were caused by human activities have been societal concerns since at least the early medieval era (Watts, 1999). Thus, it might be surprising that the term "environment," while quite colloquial, elementary and easy to define, is a rather recent concept, being less than 400 years old.

In this book we look at how human systems at the scale of the individual or greater cope with the environment. We use the somewhat unusual term "human systems" as a general denomination of individuals, groups, and human-made organizations such as companies, societies, or supranational systems. We can use different scientific disciplines, such as psychology, business science or sociology, thus broadening their use beyond only one level of human systems.

Whether humans can successfully cope with the environment depends on the environmental setting and on what they know and how they behave. The specific biophysical maritime environment of indigenous Polynesians, for instance, challenged them to develop geographically specific *environmental knowledge*, that of fishing societies (like navigation and boat-building; see Box 1.1). Amazonian Indians, on the other hand, had to develop the ability to read wildlife and flora to secure subsistence. To be successful in today's world, where competition and high-volume fishing are draining and, in some cases, damaging the very aquatic resources that sustain them, fishermen need to use modern technologies and techniques to be competitive. Such influences from technology on our environment can be seen in examples as vivid as how some

Box 1.1 The ability to read the environment: Polynesian navigation

Pacific islanders did not consider the sea a barrier but rather a highway. For navigational purposes, Samoans developed sophisticated multilayered knowledge. Star courses of many island destinations were committed to memory. By interpreting the heavens as a dome, they were able to find a bearing by reading how stars moved along paths over certain islands. On foggy days, long surface waves known as swells were used to navigate. These swells, sometimes formed by stable wind systems thousands of miles away, were considered a regular wave signal existing in the midst of other waves and chops.

For long-distance voyages it is supposed that Polynesians followed the seasonal paths of birds (see Figure 1.1). Therefore, when choosing a route, information was taken from environmental systems such as waves, winds, stars, the Sun, the Moon, birds, and the water itself (Gehmacher, 1973; Gladwin, 1970; Richey, 1974).

The Polynesians could neither read nor write and thus had to rely on their sense of sight, touch, smell, or hearing for their information. They did, however, name the stars and communicate their knowledge in songs and tales. The changing relationship between human and environmental systems can be seen by taking a wave as an example. The Polynesians had to use their eyes alone to read waves and used this information for navigation, whereas some modern surfers combine satellite remote control technology and modeling techniques to find the right monster waves (Stormsurf, 2007).

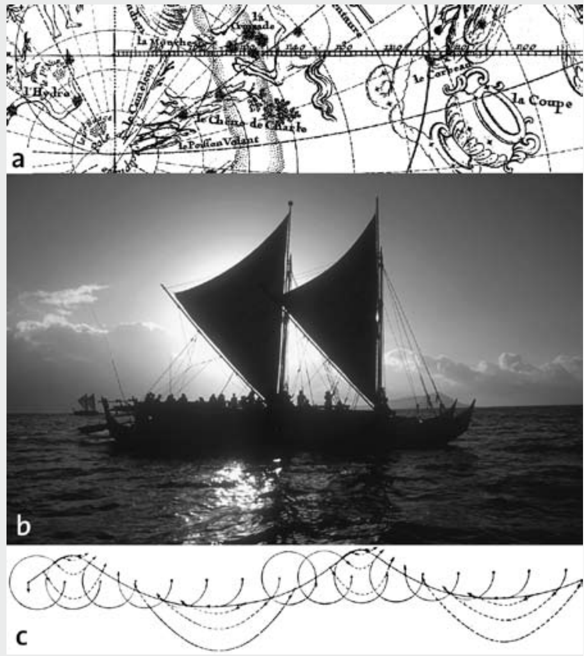

Figure 1.1 (a) Ancient map of the southern night sky (Flamstéed, 1776). (b) Polynesian sailing canoe (photo by Sam Low/Polynesian Voyaging Society). (c) The physics of waves.

of today's Surui Indians use Google Earth to monitor their fields.

Thus the *material, biophysical, and technological* aspects of an environmental setting, which comprises the *material environment*, matters. The material world consists of an abiotic layer, including atoms and their parts, water, crystals, minerals, naturally occurring carbon-based (organic) compounds and material, polymers and manmade organic compounds, as well as other objects such as cosmic matter. The built environment and machines that humans have constructed to cope with the environment are part of the abiotic layer. The biotic layer includes organisms such as bacteria, plants, and animals (Cotterill, 2008). Knowledge about the material environment is a major component of environmental literacy and is important for human systems to survive.

Knowledge about how the material environment functions and how it can serve human needs is an important issue of environmental literacy. Another issue is knowledge about feedback loops between human actions and the biotic and abiotic environment resulting from environmental actions. The environment can fire back. Rebound effects related to human health, for instance, can be traced back 450 years. The risk of developing lung cancer from radon radiation by working in underground mines was documented by Georgius Agricola (1494–1555) in the sixteenth century (Agricola, 1565).

The need to understand humans' relationship with the environment attained another level with the beginning of the industrial age and the foundation of forestry and agricultural sciences. Concerns grew about the ways in which human action changed the environment: soil erosion, flooding, (regional) climate change, etc. (Boussingault, 1845; Marsh, 1864/2003). For instance, Goudie (2006) noted that the French engineer Boussingault (1802–87) posed questions about manmade climate change back in 1845 (see Box 1.2). The age of mining, industrial and agricultural engineering required an understanding of the ecosystem functions of woods, lakes, and rivers in evaluating the

Box 1.2 Correcting negative human impacts: Ascension's spring

Forestry and agricultural sciences were the first sciences that investigated the critical effects of large-scale human impact on the environment. Therefore, questions concerning human-induced climate change had already arisen in the first half of the nineteenth century: "A question of great importance and that frequently agitated at this time is, as to whether the agricultural labors of man are influential in modifying the climate of a country or not" (Boussingault, 1845, p. 673).

The mining engineer Boussingault's original interest was in successful production and not in the environment. This is seen in the subtitle of his book, which reads: "Rural economy, in its relation with chemistry, physics, and meteorology; an application of the principles of chemistry and physiology to the details of practical farming." Thus he developed a specific environmental literacy for growing cash crops based on physiology, manure science, cultivation methods, and meteorological considerations. His questions about climate change were based on some personal hydrological observations he made between 1826 and 1830 on a small South Atlantic island:

Ascension is a small island of 91 km^2 discovered in 1501 halfway between Africa and South America. In the nineteenth century it became a stopping point for ships. "In the Island of Ascension there was an excellent spring situated at the foot of a mountain originally covered with wood; the spring became scanty and dried up after the trees which covered the mountain had been felled. The loss of the spring was rightly ascribed to the cutting down of the timber. The mountain was therefore planted anew. A few years afterwards the spring reappeared by degrees, and by and by followed with its former abundance" (Boussingault, 1845, p. 685).

The impact of deforestation was already a major topic of the new geography of the early nineteenth century (Boussingault, 1845; Marsh, 1864/2003, see Figure 1.2). Boussingault, for instance, argued that changes in vegetation on many islands such as Ascension, were a consequence of the erstwhile expansion of the Spanish empire, the freeing of slaves and land use changes such as the end of industry (i.e. plantations; Marsh, 1864/2003). Therefore, it is not only the number of people that matter but also the way they use the land.

Figure 1.2 Deforestation caused by agriculture expansion was considered to have a major impact on local and regional climate change in the early nineteenth century. (a) The Atlantic forest in Brazil by Spix and von Martius (1823–1831). (b) Jungle burned for agriculture in southern Mexico (photo by Jami Dwyer).

impact on the human species. This, in turn, challenged the major natural scientists of that century, prompting, for example, physicists to start measuring and comparing temperature dynamics in wooded and cleared areas. The Nobel Laureate Becquerel (1820–91) himself stated:

> … forests act as frigorific cause …; they shelter the ground against solar irrigation … (Becquerel, 1853, quoted according to Marsh, 1864/2003, p. 140)
>
> They produce a cutaneous transpiration by the leaves. (Becquerel, 1853, p. vi)

Thus scientists became deeply concerned about the "momentous consequences" of "human action in the physical conditions of the globe we inhabit" and pointed out the "dangers of imprudence and the necessity of caution in all operations" (Marsh, 1864/2003, p. 3).

Following the current discourse about global warming, it is most interesting to see that there was a similar dispute 150 years ago concerning whether science can reliably predict climate change and on how climate change should be evaluated:

> In my opinion we have not yet a positive proof that the forest has, in itself, any real influence on the climate of a great country, or in particular locality. By closely examining the effects of clearing off the woods, we should perhaps find that, far from being evil, it is an advantage; but these questions are so complicated when they are examined in a climatological point of view that the solution of them is very difficult, not to say impossible. (Gay-Lussac, quoted according to Marsh, 1864/2003, p. 140)

Thus, the problem of assessing and evaluating human impact on global change is both a historic and current issue. Today, we can find exactly the same statements as elaborated by Gay-Lussac about the extraordinary difficulty in providing valid prognoses on impact on climate change resulting from land cover change. The essential difference is that we are dealing with the issue on a global level. The difficulty of reliably assessing how the extremely complex climate system reacts to land cover change is clearly reflected in a comparison of seven leading climate models:

> The imposed LCC [land cover change] led to statistically significant decreases in the northern hemisphere summer latent heat flux in three models, and increases in three models. (Pitman *et al.*, 2009, p. 1)

Even though the effects from the greenhouse model seem to be much less unsure, we start to understand the difficulty in acquiring a valid understanding of the environment. This will be acknowledged in the HES framework presented in Part VIII by the Environment-first Postulate P7, whose message is that a thorough understanding of the environment has to precede human action that affects and changes the natural environment.

Another critical issue is that human systems can be arranged in the material environment in completely different ways. What is considered environmentally harmful or desirable differs between individuals, groups, companies, and societies. In some cultures, for instance, cows are sacred, and in others beef is a favorite food. The priority given to the impact of climate change differs between political parties and nations. What humans judge as a critical impact, harm or benefit, and at what point environmental interventions are initiated, depends on human interests, values, and knowledge.

Clearly, *epistemics*, the knowledge available to humans, is an important component of environmental literacy. As humans' knowledge develops and is handed down to subsequent generations, it becomes embedded as social and cultural knowledge. The knowledge that constitutes environmental literacy is also in people's minds and not only in the books, computer files, or other media that represent and store signs. Thus the socio-epistemic and cultural aspects of the human system are of crucial interest if we want to understand what creates environmental literacy. A challenge, discussed in this book, is how the knowledge and values of different parts of society can be efficiently linked to scientific knowledge.

1.1.1 Key messages

- Different geographical and biophysical environments, as well as the continuously changing world and its technological equipment, ask for qualitatively different or new types of knowledge to cope with environmental challenges
- The severe impacts, including climate change, of human activities on the biosphere by land use changes were recognized in the middle of the nineteenth century.

1.2 What drives environmental awareness?

This book introduces a conceptual framework to understand the *drivers of environmental awareness* and to provide insights into the conflicting drivers that promote or prevent *sustainable behavior*. By sustainable behavior we mean those human activities that do not endanger global dynamics, resource availability, and the resilience of ecosystems in a way that can cause problems to the self-sustaining of the current population or of future generations (Laws *et al.*, 2004). This, of course, includes the stability of human systems, which can be imperiled by socially unstable or unjust settings. We are interested in how drivers of sustainable behavior can be conceptualized, investigated, and understood. However, such an analysis on human–environment interaction includes basic assumptions about the *model of man* (see Box 1.3) that underlies the self-sustaining kind of analysis. Thus the framework presented in this book draws from the views and conceptions we have of human systems. A key issue in this context is examining the rationality behind how human systems evolve.

While we can postulate that human action occurs in response to certain goals, we recognize that humans and human systems are complex and evolve in response to many driving factors. Human actions and underlying rationales depend on situational constraints and the capability of the human system (Scholz, 1987).

Box 1.3 What type of rationale underlies human decisions? Models of man and rationality

When looking at the history of psychology, different concepts of man and rationality dominated leading scientific genres. Shulman and Carey (1984) stressed that changes of the idea or "model of man" (Simon, 1957) have been shaped by critical stages in history, particularly the twentieth century western wars. In particular, overcoming societal crises and wartimes has been the rationale behind many decisions and actions of science and society (see Figure 1.4).

After seeing the annihilation of human life during World War I, Sigmund Freud (1856–1939) put forth the death instinct theory, which describes humans as irrational beings. The theory asserts that human actions result from a perpetual conflict between a destructive "death instinct" (thanatos) and a sexually oriented "life instinct" (eros).

After World War II, there was a paradigm shift to viewing humans as rational beings. Full rationality would mean "to act consistently in its own interest – or in response to the consistency of its environment and to develop through education and learning, capacities for reason as it is mature" (Shulman & Carey, 1984, p. 501). This conception culminated in the view that human inference followed rules of mathematical models such as probability theory (Peterson & Beach, 1967).

Currently, the dominant view of humans is as bounded rational beings, with regard to judgment and decision-making. This comes from behavioral economics and other fields of behavioral sciences (Gigerenzer & Selten, 2001; Kahneman, 2003; Scholz, 1991, 1983). The principles of bounded rationality (Simon, 1982) suggest that individuals make active use of cognitive strategies and previous knowledge to deal with their memory and information processing limitations as well as their restricted operative and heuristic repertoire. There are "two camps on bounded rationality" (Jungermann, 1986). One stresses the biases and fallacies and takes a skeptical view on heuristics. The other is an optimistic view; working with a few, smart, simple, domain-specific, fast, and frugal heuristics is efficient and ecologically rational (Todd & Gigerenzer, 2007).

Another recent view, which describes humans as collectively rational beings, asserts that human ability and intelligence may only be practiced and investigated in the context of social interaction. Rather than examine human rationales via the human psyche, collective rationality and collective agency (Bandura, 2001) are dealt with on a societal level (Fischhoff *et al*., 1993; Simon, 1956). This approach involves investigating relations between specific intentions and rationality on the level of the individual *and* the society rather than on the level of rational choice theories that are based on individualistic rationales, or collective rationality from the mere side of individuals (Mahon, 2001). Collective rationality and collective reasoning refer to the benefits of cooperative reasoning, which is based on a pool of commonly accepted reasons or criticized arguments.

It is clear that the rationale of an individual rather follows bounded rationality than full rationality. Which form of collective rationality is at work seems to depend on the situation and the societal rules, cultural norms and reward systems (see Box 6.15).

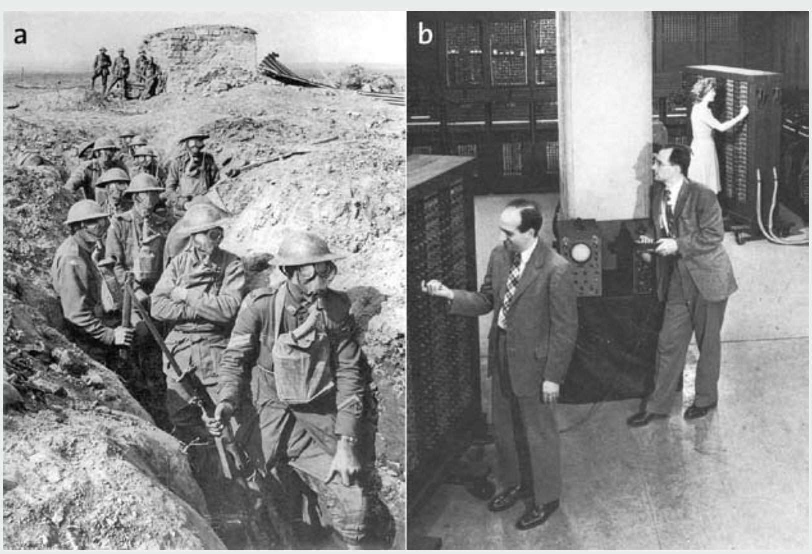

Figure 1.3 (a) World War I: Australian infantry wearing small box respirators at Ypres, Belgium in 1917 (photo by Frank Hurley). (b) J. Presper Eckert and John Mauchly with the "Electronic Numerical Integrator and Computer" ENIAC in 1947 (image courtesy of Computer History Museum).

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Roland W. Scholz
Excerpt
More information

On the level of the individual, for instance, decisions can result from multilayered, unconscious and intuitive processes that, more often than not, are based on multiple sets of goals that can even be at odds with one another.

The conceptual HES framework presented in Part VIII of this book emerges from game, decision, and system theoretical perspectives. It provides a specific language and a theoretical structure for describing human behavior from the perspective of a number of disciplines. This fits as the book contributes to what has been called "a second environmental science."

> [This] … field is the study of the feedbacks between humanity and the environment – the ways individuals, organizations, and governments act on the basis of experienced or anticipated environmental change to manage and preserve environmental values. (Stern, 1993, p. 1897)

1.2.1 Defining environmental literacy

One purpose of this book is to promote the understanding and the development of environmental literacy. By environmental literacy we mean the ability to appropriately read and to utilize environmental information, to anticipate rebound effects, and to adapt according to information about environmental resources and systems and their dynamics. Environmental literacy requires more than a fundamental understanding of the systems of the built and technical environments. It also requires a profound understanding of the potential and the limits of human systems to cope with essential settings of the biotic and the abiotic environment. Moreover, environmental literacy goes beyond understanding the impact of humans on the environment (Goudie, 2006) or assessing the effects of environmental hazards (Paustenbach, 1989). The focus is on the interaction of human and environmental systems, how humans learn from feedback and can avoid rebound effects, and what information they react to or ignore. In this manner environmental literacy is linked to learning, and so the question of how this literacy can be transmitted to future generations receives special attention. The breadth of environmental literacy, therefore, does not exclusively refer to human-induced problems. It also consists of the aptitude to adapt to natural hazards and to necessarily or reasonably cope with the changes or the potential of environmental systems.

Human systems – an individual, a company, a state agency or a nation – have to notice, discover, explore, investigate, represent, and, finally, to adapt appropriately to environmental systems. For many situations, environmental literacy is crucial to survival. As we can see from anthropology, environmental literacy has been an essential prerequisite to sustain life for presumably all indigenous people, as illustrated with the example of the Polynesian's ability to read and to *understand* a broad set of environmental information to navigate (see Box 1.1). Another example is the ability to *cope* with scarcity of resources. Today, there are mounting global concerns about the depletion of food supplies, energy, and minerals (see Chapter 11).

Environmental literacy is also essential to *assess* the human impact on natural systems such as climate, soil, water or ecosystems in a meaningful way and to *identify* rebound effects. Unintended environmental impacts and feedback inherent to human–environment systems (HES) can be seen through the example of global deforestation. Deforestation has resulted from settlement infrastructure and product development, and is also a form of collateral damage resulting from societal commerce and conflict (see Box 1.4; Schmithüsen, 2008).

1.2.2 Becoming aware of the anthropocene

This book explains that the (natural) environment cannot be considered or investigated independently of human activities. This is expressed by the term "anthropocene," which was suggested by Earth scientists to explicate that the human species has become a major geological factor (Crutzen, 2002a). This book elaborates that we need an anthropocenic redefinition of the environment. This will be done by conceptualizing HES as inextricably related and complementary systems (see Chapters 3.2, 14.1, and 16.2).

Coping with many environmental problems often calls for investigation as to which human behaviors and human systems are responsible for which environmental impact (Gardner & Stern, 1996). If we consider the western world's current concern about future energy supply, some scientists focus on individual consumerist development patterns as the lynchpin of energy depletion, climate change, loss of biodiversity, and other unwanted environmental impacts (Goldblatt, 2005). Others regard cultural norms or lifestyles of societal groups (Lutzenhiser, 1992), including sprawl settlement, mobility, or imprudent use of fossil energy for heating as the key issues. Those who deal with impacts of industrial products sometimes claim that

Box 1.4 Ignoring environmental collateral damage: British forests

The last Ice Age, which ended about 10 000 BC, covered two-thirds of the European continent with ice. Afterward, forests spread and, before agriculture began, closed forest covered up to 48.3 million km^2 and open woodland about 15.2 million km^2 worldwide. Since then, anthropogenic activity has reduced forest cover, and today closed forests have been reduced by about 7–8 million km^2 and open woodland by more than 2 million km^2 (Williams, 2000). The largest losses have come from agricultural activity and urban residential development, along with demand for timber and firewood.

McNeill (2007) elaborated that, historically, warfare played an important role in deforestation. Forests supplied the earliest weapons, such as clubs, spears, slings, bows, and arrows. Deforestation continued into the Bronze Age, as places like Cyprus, a major copper supplier in the Ancient Mediterranean, used timber to fuel and fire copper smelters. In addition, most agricultural societies built defensive fortifications from wood, and coastal societies protected the timber supplies they needed for shipbuilding. For instance, the seafaring Phoenicians defended Lebanon to maintain their access to high-quality ship timber (McNeill, 2007). Given that an "eighteenth-century-ship required four thousand mature oaks … or about twenty hectares of northern European forest" (McNeill, 2007, p. 8; see Figure 1.3), it is not surprising that forest ownership resulted from economic and imperial interests. Spain was an early global timber trader, importing wood from Italy, the Balkans, and Brazil. In addition, about 35% of its naval shipbuilding took place in Cuba, which became its most important colony. Timber remained a significant source of war material into the twentieth century as well (Gardner & Stern, 1996, 2002). Between 1916 and 1918, Britain felled half of its productive forests to meet the needs of the war.

There are other examples of unintentional, or "collateral," damage resulting from wartime activities. For instance, in 1741, some 10 000 men were assigned the task of clearing West African woods in preparation for a full-scale battle. As a tactic against guerilla resistance, forest burning has been a common practice by many groups since the time of Roman legions. During the Vietnam War, 23% of old forest was cleared (all data taken from McNeill, 2007).

All this occurred in spite of the (theoretical) knowledge that deforestation could lead to decreases in soil productivity and changed water balances ending with desertification and societal collapse on a large scale, as formulated by Marsh (1864/2003). Today, we have evidence that deforestation along the southern coast of West Africa induced desertification along the border with the Sahara (Zheng & Eltahir, 1997). Also, Amazon deforestation is a major component of climate change (Shukla *et al*., 1990), although there is uncertainty about the exact impacts on regional and global scales (Pitman *et al*., 2009).

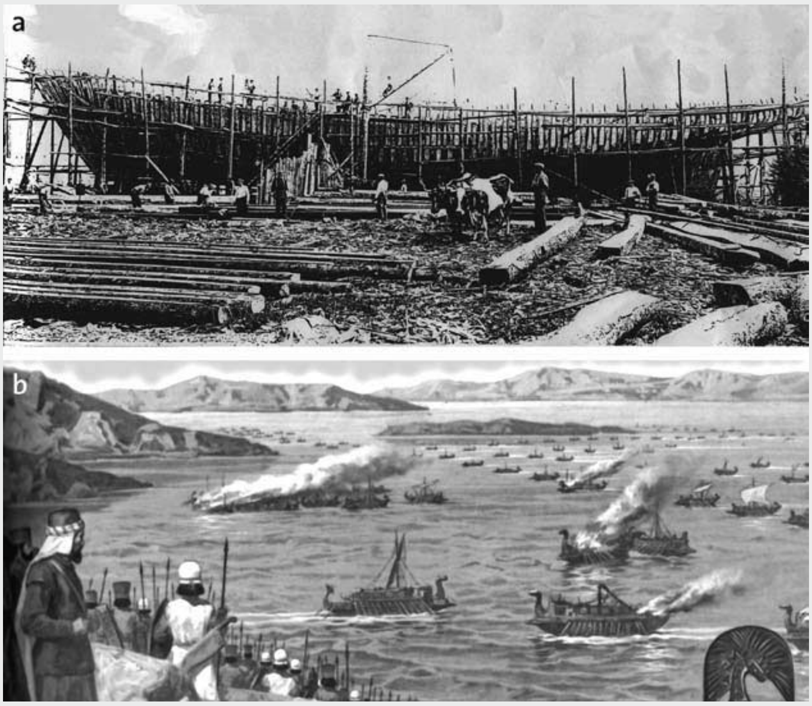

Figure 1.4 (a) Shipbuilding in 1917 at Lockhart Shipyard in Nova Scotia (Deal, 2006). (b) In the naval battle of Salamis between the Greek city-states and Persia in 480 BC, more than 1300 triremes were involved (painting by unknown artist).

also responsible business companies or technology developers may become important agents of sustainable development (Robert *et al.*, 2002; Schmidheiny, 1992). In principle, we elaborate that successfully coping with environmental impacts and feedbacks requires adequate mitigation and adaptation strategies on different levels of human systems (see Figure 14.1*).

Many researchers in the field of sustainable development look at highly aggregated systems and investigate uncontrolled world population and the related economic dynamics of the human species as origins for resource depletion (Ehrlich & Ehrlich, 1970; Ehrlich & Kennedy, 2005; Meadows *et al.*, 2004; Robert *et al.*, 2002). Interestingly, it seems that the issues of regulating world population and successfully negotiating compulsory mitigation and adaptation strategies among the nation state-governed world system has become taboo or at least a background issue. As elaborated in the sociology section in Chapter 8 and in the Hierarchy Postulate P2 in Chapter 16, supranational institutions can and should take a major role for a global development agenda (Beck, 2000; Beck & Sznaider, 2006; Bernauer, 1995; Tallberg, 2002). There are other challenges of environmental awareness and environmental literacy, such as being able to identify the most sustainable environmental protection interventions in situations where the trade-offs between different interventions are not clear. Another fundamental challenge is having the capability to recognize changes that signal irreversible shifts in ecosystems, such as noticing the disappearance of lynx from the Harz Mountains in Germany, which led to an overpopulation of deer. These are discussed in the following chapters.

1.2.3 Key messages

- Environmental literacy denotes "the ability to appropriately read and use environmental information and to anticipate rebound effects or to adapt according to information about environmental systems and their dynamics"
- There are different types of rationality which can be supposed to underlie human behavior
- Becoming aware of the biophysical environment and utilizing it is a basic prerequisite for human existence
- The impacts of human systems on environmental systems have attained a magnitude that suggests humans have become a geological factor. This calls for an anthropocenic redefinition of the environment from an inextricably coupled, complementary systems perspective
- Sustainable behavior requires appropriately reading of the limits, unwanted and long-term dynamics, and rebound effects emerging from the material, biophysical and technological environment, as well as from the social environment. Justice can be seen as an important trait of stabilizing human systems.

1.3 Who invented the environment?

Earth scientists suppose that the Big Bang occurred about 13–14 billion years ago (Spergel *et al.*, 2003) and the emergence of life occurred about 3.8 billion years ago (Nisbet & Sleep, 2001). Paleontologists estimate that the first mammals appeared 65 million years ago (Rose, 2006), and anthropologists estimate that the emergence of *Homo sapiens* was between 195 000 and 50 000 years ago (McDougall *et al.*, 2005). The founding of cities dates back about 5000 years (Benevolo, 1980).

In comparison, the term "environment" is a relatively recent concept that appeared less than 400 years ago. It has a most intricate history, with multiple, different meanings. Some may find this surprising, particularly against the background of the twentieth century in which the term environment has been ubiquitously used and thought of as having a historically constant state (Müller, 2001). Etymologically, "the state of being environed" in the sense of "nature, conditions in which a person or thing lives" (Harper, 2001) can be traced back to 1603 and was first recorded by the Scottish historian and freethinker Thomas Carlyle, who translated a description of Ossianic landscapes:

> In such an element with such an environment of circumstances[1], with studies and tastes of this sort; harassed by unsatisfied desires … (Carlyle, 1827; quoted according to Spitzer, 1942, p. 204)

The quote is typical for the time of *Sturm und Drang*, "storm and stress," a movement in German literature and music that took place from the late 1760s to the early 1780s, which dealt with extremes in emotions and feelings. Given the context of this phrase and the erotic shape of Ossianic landscapes used by Goethe (see Box 1.5), it was clear that the term environment (and landscape)

[1] German: "… bei solcher Umgebung bei Liebhabereien und Studien …" The translation "… in such an environment of desires …" seems to be a more appropriate translation.

was used to describe what might be called a (imagined) social environment (Slater, 1952). The focus here is on the complex of surrounding conditions, social and cultural conditions, the milieu, and influences affecting an individual. Thus, the terms "social milieu," "ambience," and "environment" have been used interchangeably in language (Spitzer, 1942, see Figure 1.5). Similarly, Carlyle (1831) employed the term "the environment" in a phrase to describe Bayreuth: "The whole habitation and environment looked overtrim and gay" (Carlyle, 1831, quoted according to Spitzer, 1942, p. 205).

1.3.1 From environment to total environment

The term environment had a "vague and intangible reference at the beginning" in the context of "biologico–sociological" discussions (Spitzer, 1942, p. 176). These discussions among biologists, psychologists and sociologists scrutinized the way in which the technical term of science "biologico–sociological" evolved into the notion of the term environment. Spitzer was not overly fond of Carlyle's translation of Goethe (1749–1832) and noted that the term environment took on new meaning during scientific discourse of pre-evolutionary topics. For instance, Jean-Baptiste Lamarck, a zoologist who invented the term "biology" by subsuming morphology, physiology and psychology (Ballauff, 1971), proposed that evolution has its origin in the loss or development of characteristics depending on the intensity of use of these organs stipulated by the milieu and circumstances. Lamarck's idea that an individual is adapting (see Box 4.7) was later replaced by Darwin's theory of species adaptation through the interplay of variation and extinction (see Chapter 4). Historically, in this context, the term environment

> took a new power … in 1855, when Herbert Spencer, who coined the phrase of survival of the fittest, published his *Principles of Psychology* … and his pre-Darwinian theory of evolution. We can see "environment" shifting in Part 3 of the book … Spencer takes us from [a] single organism

Box 1.5 The double environment: Ossianic dreams

The first use in English of the term "environment" was by the Scottish poet and freethinker Thomas Carlyle in 1827. He created the term when translating desires and passions as they had been presented in Ossianic landscapes, which exuded a character of romantic idealism (see Figure 1.5).

From a semantic perspective, the term environment has several predecessors, such as circumstance, setting, ambient, milieu, milieu ambient, "tout ensemble," etc. (see Figure 1.6). When dealing with the etymology of many languages (e.g. Italian, English, French, German), the thorough historic analysis of Spitzer (1942) reveals that all of these terms were related to a physical, material, and geometrical (locus) meaning as well as to a social, immaterial notion. For instance, the term "milieu" (middle of a place, "lieu" being French for place) referred to the Latin *medius locus* (i.e. middle) and has been used by the mathematician Pascal to argue for the golden section. But all these terms, just as the later term environment, also had social, moral, and epistemic notions not substantiated by the ideal of a material–biophysical environmental rationale.

Figure 1.5 The dream of Ossian (painted 1813 by Ingres).