2

Defining the Challenge

Background

In the early years of the current century, Will Steffen and colleagues (2004, 2005) published a couple of illustrations that summarized our understanding of global change in a very effective way, showing how, since 1750, changes in the Earth system had accelerated very rapidly. To do so, he combined in two figures measured changes in environmental and societal parameters, ranging from CO_2 and NO_2 emissions, loss of biodiversity, and increases in Earth surface temperature to the number of people worldwide, gross domestic product (GDP), and water use (see Figure 2.1). These figures were reproduced in many publications and became extremely well known and popular at a time when the scientific world was principally looking at global change in the context of different scientific disciplines.

A few years later, in a paper in *Nature* that has also been frequently cited, in a team led by Johan Rockström of the Stockholm Resilience Center (Rockström et al. 2009a), we made for the first time a strong case for the fact that our worldwide management of the environment was exceeding what was called the "safe operating space" of the Earth's environmental dynamics. Much of the debate that followed focused on the question whether it was possible to a priori set global limits to such a space, or even whether such an approach was conceptually sound. Another part of the debate questioned the boundaries themselves. But relatively little attention was paid to an important message: the fact that if human activities pushed the Earth system dynamics beyond certain limits *in more than one dimension* (e.g. CO_2 emissions, biodiversity loss,

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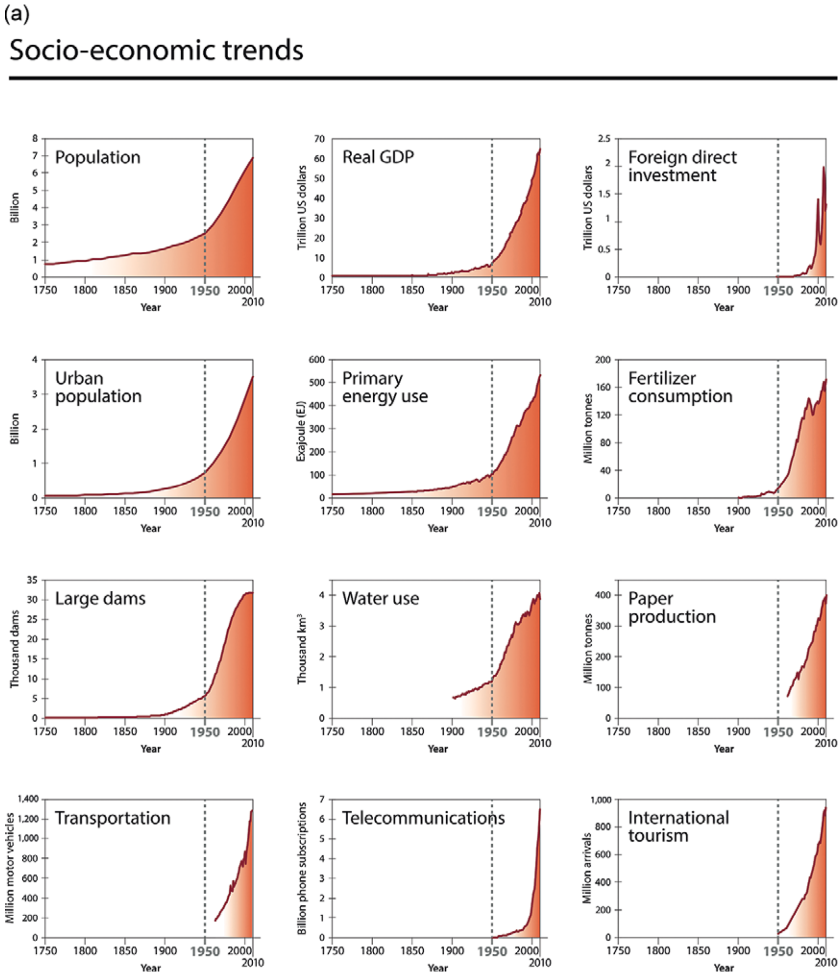

FIGURE 2.1a,b The rapid acceleration of change over the last 2½ centuries viewed through the eyes of many dimensions, both natural and societal. (Source: Steffen et al. 2015, *The Anthropocene Review*, by permission SAGE)

ocean acidification, etc.), the system as a whole could easily move into completely unpredictable, (near-) chaotic behavior, rapidly undermining the environmental bases of our various societies.

The paper, and a subsequent one headed again by Will Steffen (2015), thus not only drew attention to the fact that our Earth system was undergoing rapidly accelerating change in many environmental as well

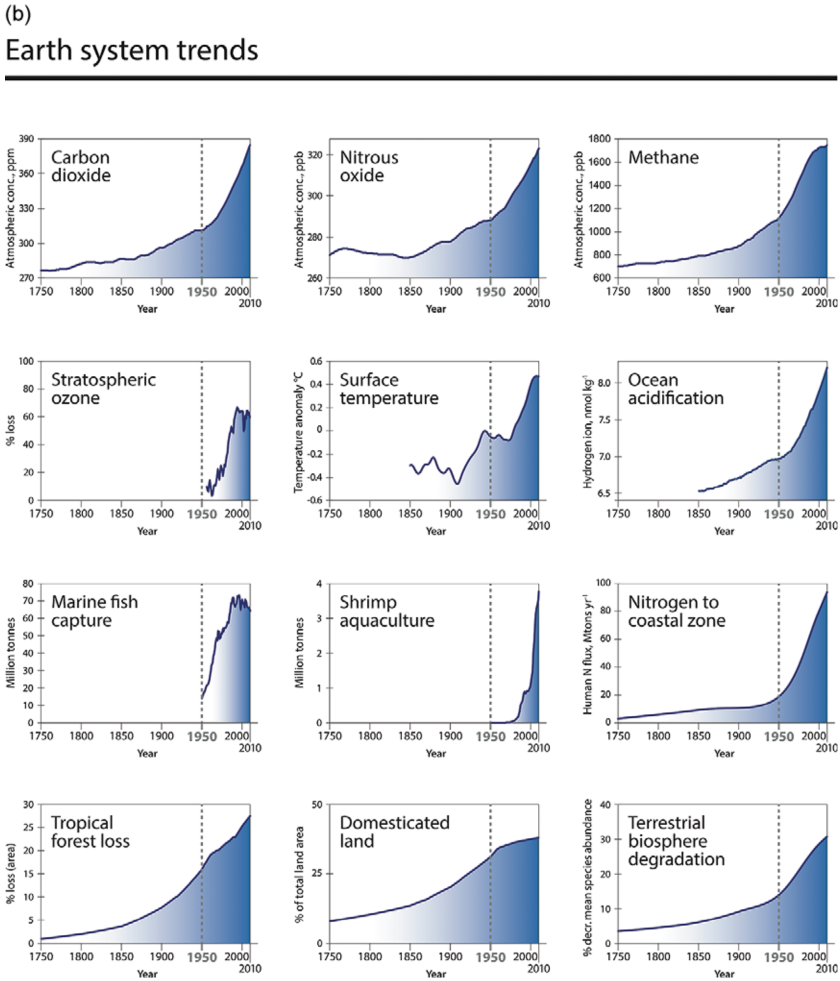

FIGURE 2.1a,b (*cont.*)

as societal dimensions, but that there might come a point where these many changes would themselves generate second-order changes (that is, changes in the nature of the dynamics themselves, dynamics which during most of the Holocene have remained within narrow boundaries) that could rapidly and unpredictably transform the natural as well as the societal sphere in which human groups have functioned for centuries. By implication, these papers argued for a transdisciplinary approach that involved the atmospheric sciences, chemistry, oceanography, geology,

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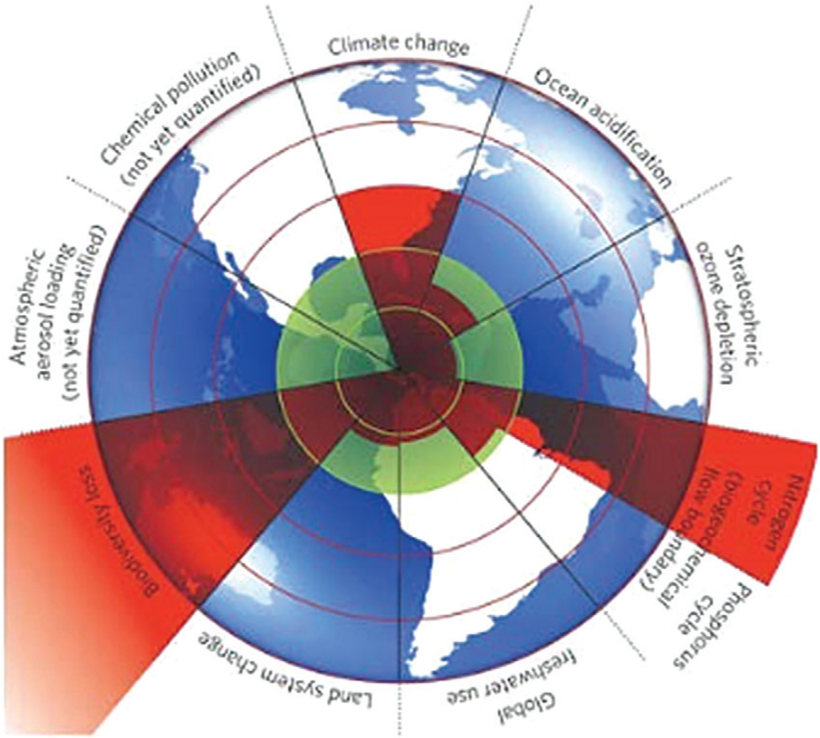

FIGURE 2.2 The Earth system is close to exceeding its "safe operating space." (Source: Rockström et al. 2009a, *Nature* by permission)

biology, and other disciplines. But they did not include the social sciences in equal measure.

This intellectual shift occurred in parallel to an organizational shift in the global scientific community's institutional context. In the 1980s and 1990s, a number of Global Environmental Change communities had been created and funded that grouped certain disciplines together: the World Climate Research Program (1980; climate sciences, meteorology), the International Geosphere-Biosphere Program (1986; Earth sciences, life sciences), the International Human Dimensions of Global Environmental Change Program (1990; social sciences), DIVERSITAS (1991; biodiversity-related disciplines such as ecology), etc.

An important aspect of this situation was that this movement involved the upstream part of the Earth science community alone, while in other scientific fields (physics, chemistry, biology, etc.) there usually are large "intermediate" scientific communities dealing with "applied sciences" before the scientifically acquired knowledge can be adopted for technological, industrial, agricultural, medical, and other applications. This shortcut created a wide disconnect between the Earth science and sustainability communities on the one hand and the general public as well as all people involved in doing things (engineers, politicians, professional organizations, etc.) on the other. In the latter sphere, because knowledge is immediately related to "needed actions" and their consequences, scientific knowledge is mainly approached as emotion (how many images have we not seen of polar bears deriving on melting icebergs?), rather than rationally with reference to the means to act. Action is all too often caricatured as being in the hands of a business community that is only interested in short-term profit.

In 2006, at a meeting in Beijing, a new organization was created, the Earth System Science Partnership, which was conceived as an organization to start building the links between these different communities. This proved difficult, and was quickly abandoned as an effort, to be replaced by a complete reorganization of the whole Global Environmental Change community into a single organization, called Future Earth. This was initiated in 2012 and is nearing its cruising altitude and speed as I write. As part of that transition, an explicit focus on learning for the future, transdisciplinarity, co-design and the development of applications is included in Future Earth's vision, but in practice the organization is still very much driven by the academic community and its longer-standing approaches.

Both intellectually and organizationally, the first decade of the twenty-first century thus saw a clear move toward investigating global change in an integrated, transdisciplinary manner. It seems to reflect a fundamental conceptual change that began a couple of decades earlier, in the 1980s, which changed our conception of the relationship between people and their environment, as summarized in Table 2.1.

The last few decades have seen a shift in our understanding of the relationship between societies and their environments. Up to the 1980s humans were predominantly seen as (reactively) adapting to nature. Under the impact of the environmentalist movement, the late 1980s and 1990s saw the emergence of the opposite perspective: humans as pro-active, with (mostly negative) consequences for the environment. That led to the emergence of sustainability as an ideal. In the late 1990s and 2000s a more balanced perspective emerged, which views the relationship between societies and their environments as interactive. The core concept

Table 2.1 Shifts in the conceptualization of society's relationship to nature

Pre-1980s	*1980s–1990s*	*2000s*
Culture is natural	Nature is cultural	Nature and culture have a reciprocal relationship
Humans are re-active to the environment	Humans are pro-active in the environment	Humans are interactive with the environment
Environment is dangerous to humans	Humans are dangerous for the environment	Neither are dangerous if handled carefully; both if that is not the case
Environmental crises hit humans	Humans cause environmental crises	Environmental crises are caused by socioenvironmental interaction
Adaptation	***Sustainability***	***Resilience***
Apply technofixes	No new technology	Minimalist, balanced use of technology
Milieu perspective dominates	Environment perspective dominates	Attempts to balance both perspectives

Source: van der Leeuw.

shifted again, this time to resilience – the capacity to respond to change without losing continuity or identity.

But in many relevant scientific communities, this shift is not yet complete. In the climate, Earth and life sciences in particular, the role of societies is acknowledged, but many in these disciplines still see that role as defined by, and often ancillary to, the role of atmospheric dynamics, geological or geomorphological processes, ecosystems, etc. Thus, when practitioners of those disciplines formulate questions that they hope can be answered by social scientists, they (understandably) do so in ways that derive from their discipline of origin.

A central theme of this book is the fact that our so-called environmental challenges are in fact *societal* ones, involving all aspects of our societies, including governance, economics, culture, technology, institutions, environment, resources, etc. I use this term throughout the book to distinguish the dynamics involved from purely social ones. At the most fundamental level the distinction between society and nature is a societal one. As I will explain in Chapter 3, the concept "nature" emerges in its current position as a counterpart to "culture" in the eighteenth and nineteenth centuries in western Europe in an attempt to define natural

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history (biology) by contrasting it with history (the history of societies and human individuals) (van der Leeuw 1998).

The questions asked by the natural and life sciences often do not hit the sweet spot among social scientists, and do not trigger the kind of research effort that, fundamentally, they merit in view of the urgency of dealing with the socioenvironmental issues involved. It is often as if there is a glass wall between the disciplines involved: they see each other, but they cannot touch. I will discuss the historical reasons for this in Chapter 3.

What concerns me here is rather to present a first outline of the task of reaching out across that barrier, to achieve the kind of intellectual fusion that is necessary to deal with the issues concerned. As a starting point, I think we have to acknowledge that most of the kinds of scientific challenges that the social sciences deal with are very different from those tackled by the natural, life and Earth sciences. One way this difference has been formulated is by Cristelli et al. (2012), who show an image of one of the US astronauts on the moon, alongside an image of a huge traffic jam in London and ask "Why can we reach the moon but not the airport?"

The answer is that these are two very different kinds of problems. Reaching the moon is not easy, but at least the goal is well defined, and the number of dimensions involved is limited and knowable, so that the challenges to be met and the dynamics affecting them can be isolated, the overall challenge disaggregated into subsets and solutions found for these subsets. Once such solutions have been found, one can then bring the subset solutions together to meet the overall challenge. Many of the problems in the natural, earth, and engineering sciences are of this nature. Once they have been solved, they will not recur as problems. They are considered "tame" in comparison with "wicked" problems.

In their image, the way to the airport is blocked by a traffic jam. Traffic jams are examples of such wicked problems, problems that cannot be solved definitively. The number of dimensions involved is so large that it is unknowable, and the challenges can therefore not be disaggregated. Such problems are characterized by indeterminacy in problem formulation – the precise formulation of a wicked problem as a problem with unique and determinate conditions to be satisfied is virtually impossible – and by the fact that there is no definite and rigorous ultimate solution with definitive results. Such problems can at best be suppressed, managed, or solved over and over again (Rittel and Webber 1973). Most challenges involving society are of this kind – if only because the behavior of so many individuals is involved. Other examples of such wicked problems are the "Not In My Back Yard" (NIMBY) problem, the recurrence of financial crises, and terrorism.

Such differences in the nature of the issues investigated, as well as the (related) differences in disciplinary history, research goals, paradigms, methods, and training have led to (groups of) disciplines that collect their data under the impact of different epistemologies, using different methods and techniques, and set different standards for the validation of research results. Hence the data and information collected and used by these disciplines cannot be treated in the same manner, and that constitutes another fundamental barrier to developing an integrated perspective on socioenvironmental dynamics. This is aggravated by the fact that many scientists in both the disciplines related to the Earth sciences and the social sciences and humanities disciplines, as well as politicians, business (wo) men, journalists, and others are only partly aware of the fundamental epistemological and conceptual differences behind their disciplines, which in many instances leads to confusion, and therefore to ambiguity concerning the nature and value of the data collected.

One reason for this semi-awareness is the nature of our education systems, which are so strongly discipline-based and discipline-focused that they develop their own communities of practitioner-experts, their own education curricula, their own specialist languages, their own funding sources, and above all their own criteria for admission into a particular field of study. These different fields of study focus on particular issues, questions, methods, and techniques, and relegate to other communities of scholars and scientists the task of answering questions that they themselves cannot. In this process of – for want of a better term – educational and social alignment, many academic – disciplinary – communities have increasingly closed themselves off from scientists and scholars in other disciplines because it became increasingly difficult for those who had not followed the anointed *cursus honorum* of a discipline to achieve the full depth of understanding of its expert practitioners. As a result, the scientific worldview that was once the pride of the Enlightenment has fractured into many disciplinary academic ones, and that state of affairs has been cast into administrative structures in (almost) all universities and research organizations. But it should be pointed out that this is not the case, or at least not to the same extent, among the applied science-, technology-, engineering- and related communities that have to an important extent been industry or business -driven.

Once a sufficient number of scholars and scientists became aware of this issue, they initiated a swing in the opposite direction, emphasizing consecutively "multi-," "inter-," "trans-" and most recently "un-" disciplinarity. That battle-cry is now resounding everywhere, but in practice, for reasons to be discussed later, it is personally and institutionally still very difficult to achieve the kind of intellectual fusion that is needed to deal with complex questions such as sustainability. I would like this book to contribute a vision of the challenges facing us that enables an improved intellectual fusion between the disciplines involved by providing the necessary scaffolding structure.

In order to do so, I have adopted a starting point that is very different from most of those involved in the sustainability debate. Rather than view our current socioenvironmental dilemma from the perspective of the natural and Earth sciences as is done, for example, by the Intergovernmental Panel on Climate Change (IPCC) I will do so from a societal perspective, in keeping with the thesis expressed in Chapter 1, that the second order drivers that are increasingly pushing the socioenvironmental dynamics of our Earth system to transgress the boundaries of our "safe operating space" are essentially societal, not environmental.

The argument for that is quite simple. Everything humans observe and do passes through the filter of their cognition. That filter defines all the categories humans simultaneously observe and create. Hence, both "nature" and "culture" are in effect cultural categories, defined by humans who have adopted different perspectives on the world around them. Environment is another such culturally defined category. Humans define what they consider their cultural and natural environments. They also define what they consider the challenges they observe in these environments, and finally they determine what they consider to be the "solutions" for such challenges. Other cultures than our own, western one define their environments differently. In some instances they do not in any way distinguish the cultural or social sphere from the natural and environmental one (as in the case of the Achuar, see Descola 1994), while in other cases they acknowledge a difference between these spheres but conceive the relationship between them in ways very different from our own, as for example in Japan (Berque 1986). But even when a group does not distinguish between "culture" and "nature," that in itself is a sociocultural choice. It is thus not only appropriate but essential that we view socioenvironmental dynamics as being societally driven. This will be of fundamental importance in the sustainability debate in the current century, in which major societal changes are likely to occur.

The choice to try to develop an integrative (transdisciplinary) perspective on socioenvironmental dynamics from the societal point of view brings a novel, daunting challenge: to introduce a perspective on societal dynamics that engages natural, life, Earth, economic, and social scientists, so that they can all contribute to its development. Moreover, that approach should not only be able to provide proximate explanations for observed phenomena, but also ultimate explanations for both the first- and the second-order socioenvironmental dynamics we observe in all three so-called pillars of sustainability: society, economy, and environment.

To find a starting point, I have argued as follows: if we consider for a moment human beings as "just another unique species" (the title of Foley's 1987 book), I think we can agree that, like all other living beings, humans process energy, matter, and information. They use energy and matter to physically live and survive – to feed themselves, to grow, and to reproduce. Some of that energy is processed in the form of raw energy – heat from sunshine, for example, which is transformed into vitamins and absorbed to help maintain the necessary body temperature. The remainder of the energy needed to maintain body temperature, as well as the energy expended in movement and other muscular activity is processed in the form of matter – food. Other forms of matter, and this distinguishes humans from many other animals, are processed to provide protection, tools, shelter, and the like. In all these cases, the processing involves the transformation of the information content of the matter, either through digestion (increase of entropy) or creation of functional objects (decrease of entropy).

Humans, like all other animals, therefore also process information. But what is specific about human beings is that they not only learn (and learn how to learn, see Bateson 1972), but they can (and do) organize (Lane et al. 2009b). In organizing, they add information to matter and energy when they transform either or both for a specific human purpose. They organize their thoughts, their needs, their actions, their tools, and they also organize themselves – into communities and societies. In doing the latter, they put to use a particular aspect of information – the fact that it is not subject to the law of conservation. Energy and matter, because they are subject to this law, *cannot be shared*, but information *can be*, and is, *shared*. A society functions as such because its members communicate and share ideas, expectations, ways of doing things, knowledge about certain resources, etc. It is the sharing of information that holds a society together and constitutes its culture. The fact that information is processed both individually and (in later human prehistory) collectively is responsible for the fact that each culture has its language, its customs, its technology, and material culture, its myths and legends, its art, etc. All of these are shared and communicated ways of doing things.

One could in effect say that each and every individual and society processes energy and matter, but what distinguishes individuals and societies is the *form* that such processing takes, and that in turn is dependent on the information processing of both the group and the individuals that are its members. André Leroi-Gourhan was as far as I know the first to point in this direction in the mid-1940s in his *Technique et Langage* (Technique and Language), part of a magnificent set of two volumes on many of the contextual dimensions that impact on techniques and technology, including long-term history, materials, cognition, economy, and tradition.

Taking the above argument as the starting point of my search for a perspective on societal dynamics that can engage scientists on both sides of the social–natural sciences divide, I have looked at a number of aspects of human dynamics from the information-processing perspective, and will introduce these explorations in later chapters (Chapters 8 ff.) of this book.

Six Fundamental Points

In order to give the reader a synthetic preview of some of the main points that have shaped my perspective on sustainability issues and that underpin much of this book I want to present six major points in a nutshell.[1] The reader will see them recur as part of the weft of the book.

The **first** of these, that *we are facing a societal rather than an environmental crisis* has already been referred to: societies define what they consider their environment, what they consider its problems, and what they see as the potential remedies for the latter. Or, as Luhmann (1989) emphasized, society does not communicate with its environment, it communicates within itself about the environment, and such communication is self-referential in each culture. We cannot escape the fact that our societies are responsible for the environmental phenomena that cause us to worry, and only by changing our collective behavior can we do something fundamental about these worries.

A first step in that process is to understand the societal dynamics behind the environmental crisis, including the role of science itself – its overpromising, its unintended consequences and their negative effects, as well as its numerous positive contributions to many aspects of human life and society. We need to ask, for example, what is the role of science in the fact that there is such a protest against Genetically Modified Organisms

(GMO's) in Europe and there was much less on nuclear issues? This also touches on the role of scientific communication – which five or ten years ago was not on the agenda.

The **second** point I emphasize is *the importance of looking at dynamic systems over the long term*, sometimes up to several millennia. This allows me to discern aspects of systems dynamics that are not usually included in shorter-term visions:

- Slow changes that do impact on the environment and society, but are barely discernible at secular timescales;
- A wider range of system states than the ones that the system has encountered over the last few centuries;
- Second order changes ("changes in the way change proceeds") that reveal important dynamics that often play out very slowly.

Moreover, looking only at the last two centuries or so, we observe a socio-natural system that has already been heavily impacted by anthropogenic dynamics. It is like looking at a very ill patient without knowing what a healthy person looks like. Taking a long-term perspective enables one to distinguish the natural dynamics better from the anthropogenic ones.

My **third** point is that we have to look at *the limitations of human cognition*. Human cognition, whether individual or collective, is limited to a relatively small number of the dimensions of processes occurring in nature. Our actions, which are thus based on partial – and biased – perceptions of the dynamics going on around us, affect our environments more profoundly than we can possibly know. At the 2016 Royal Colloquium in Stockholm Taleb (2017) has called this "the curse of dimensionality." Over time, the net effect of continued learning about, and intervention in, the environment is that the more we think we know, the less we know because we have wrought changes in the environment that far exceed our knowledge. This results in unanticipated, unintended consequences of our actions. Moreover, whereas we "do something about" known frequent risks, these actions engender unknown risks that accumulate over time so that the risk spectrum shifts over the long term toward a dominance of unknown, long-term risks.

This second-order dynamic is reinforced by the fact that our thinking is underdetermined by current observations (Atlan 1992) and thus over-determined by known reactions to prior events Hence, our thinking is path-dependent and difficult to change. The actions we conceive and implement fall within a range determined in the past, and they are therefore very often not optimal to deal with the changed circumstances.

Due to the shift in risk spectrum and the introduction of unknown longer-term unintended consequences, over time the latter accumulate to the point that a society may no longer know how to deal with all of them simultaneously. This is in my opinion what triggers a crisis or (in more scientific terms) a tipping point, a temporary incapacity of a society to do the information processing required to keep it in tune with the changes it has caused. It follows that we must look closely at these unintended consequences of all our individual and collective decisions and actions.

My **fourth** point, following directly from this argument, is that we *have to also invert the way we look at stability and change*, by assuming that change is permanent and humans try and create stability, so that we should be explaining stability rather than change. This is a very fundamental move away from our core Aristotelian scientific perspective toward the perspective of Heraclitus of Ephesus. It implies among other things that we should start to design for change, rather than for stability, such as is timidly being proposed by the protagonists of the circular economy. Another implication is that wherever possible we should follow the precautionary principle, making "do not harm" the core of our interactions with our environment.

The **fifth** point is that the current emphasis in the sustainability community on "innovating our way out of trouble" ignores that 250 years of randomly exploding innovation in every domain is what got us into trouble with the environment, as has wonderfully been illustrated by Klimek and AtKisson's *Parachuting cats into Borneo* (2016). To have any chance of dealing with our present global predicament, we must ultimately find ways to focus innovation in positive, helpful directions. But currently we do not even know scientifically how invention works, and we only partly understand how the introduction of inventions in society works (Lane et al., 1997, 2005). We need urgently to understand this better, in order to focus our innovative capacity on sustainability issues.

My **sixth** point is to ask *why do we forever push against the environment*, trying to transform it, at least in our western societies? Our relationship with the environment can be seen from two points of view – that of the society and that of the environment, which I am here referring to as *environment* (the natural state surrounding society) and *milieu* (society in the center of nature) respectively. Those perceptions interact, according to an interesting perspective on category formation (Tversky & Gati 1978; van der Leeuw 1990), in which the direction of comparison between a subject and a referent with which it is compared

Table 2.2 Different perspectives on the relationship between humanity and the environment

Milieu	*Environment*
Humanity is compared to nature;	Nature is compared to humanity;
The cohesion of nature, its unknown aspects, its strangeness and force are amplified;	The cohesion and strength of nature is diminished, its known aspects are emphasized;
The confusion and the handicaps of humanity are accentuated;	Cohesion and strength are accentuated in humanity;
Humanity is *passive* in a natural environment which is *active* and aggressive;	Humanity is active and aggressive in a natural environment that is *passive;*
Change is attributed to nature, and people have no other choice but to adapt to nature;	Humanity is the source of all change; people create their environment; often with negative effects for nature
Natural changes tend to be viewed as dangerous, because they are beyond human control.	Natural changes seem more controllable and lose their dangerous appearance.

Source: van der Leeuw (2017).

determines whether the comparison emphasizes similarities or differences. Thus, when in the *milieu* perspective humanity (subject) is compared to nature (referent), the cohesion and strength of nature and the confusion and handicaps of humanity are emphasized, whereas in the *environment* perspective, when nature is the subject and humanity the referent, the opposite happens. This leads to the opposition illustrated in Table 2.2.

If we then look at how these two perspectives interact, one sees that taking them together, they exaggerate the unknown dangers of the environment, and downplay the dangers of human intervention in it, explaining in my opinion the opposition between society and environment and the continued intervention of the former in the latter.

This raises an interesting question: where does one focus first – on the context or on the subject, on the ideal or on the reality? What does one consider the subject, and what is seen as the referent?

In this context, there are two interesting differences between a western and an eastern (Daoist) perspective (Sim & Vasbinder, in press). Firstly, in the latter one seems to focus first on the context, and then on the subject, whereas in the West it seems to be the other way around. If that is indeed the case – and I am not at all a specialist in these matters – that would imply that in the Daoist approach the similarities between society and the environment are emphasized, whereas the differences are emphasized in our western approach.

Could it be that this difference is also related to the fact that in our western approach, at least since the Enlightenment, one projects an ideal and strives to get as close to that ideal as possible whereas in a Daoist approach, on the other hand, one tries to act in the best way possible given the context of the moment, rather than strive toward an ideal?

NOTE

1 The final section of this chapter closely aligns with van der Leeuw (2017).