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Kropp | Sonnberger

Environmental Sociology

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Cordula Kropp | Marco Sonnberger

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Foreword

As we completed our work on the English version of this introduction to environmental sociology in October 2024, media reports were filled with news of escalating disasters. In Spain, torrential rains had just caused flash floods, resulting in more than 200 deaths, Australia saw its hottest September in record, with temperatures 3°C above the long-term average, causing health problems for both human and non-human beings. Globally, summer 2024 was the Earth's hottest on record, and in August 2024, the average land temperature in Europe was 1.57°C above the 1991-2020 average, according to the Copernicus Climate Change Service. In 2023, nature's carbon sink failed for the first time, with trees, plants and soil showing almost no net absorption of carbon dioxide emissions due to enormous forest fires and rising sea temperatures. In Canada alone, 6,623 wildland fires had burned more than 15 million hectares of managed forests. "We're seeing cracks in the resilience of the Earth's systems … the oceans showing signs of instability"[1] said Johan Rockström, director of the Potsdam Institute for Climate Impact Research, about these phenomena, which are not yet factored into climate models. Extreme weather events have already become part of our normality, and local governments around the world are urgently developing climate adaptation strategies to keep cities habitable. In each of these regions, institutions struggle to manage climate impacts, highlighting a troubling lack of preparedness and action capacity. At the same time, continuous updates of the planetary boundaries framework in Earth sciences' find that six of the nine boundaries are transgressed, "suggesting that Earth is now well outside of the safe operating space for humanity" (Richardson et al. 2023: 1). Now more than ever, future generations must confront the urgent task of reimagining lifestyles and economic practices, working towards their sustainable transformation. We believe that environmental sociology has a great deal to offer in this endeavor. This textbook is particularly relevant for students in social sciences—sociology, political and communication sciences, human geography, psychology—where an understanding of environmental sociology has become essential for a well-rounded education that meets today's needs.

With this in mind, we hope this English translation of our introduction to environmental sociology reaches a broad audience. Our goal is to provide students and other interested readers with a comprehensive overview of key theories and research in this essential field. The book offers a theoretical and thematic guide to the major issues and approaches in environmental sociology. While our coverage, based in Germany's long tradition in environmental sociology, is necessarily selective, we aim to present foundational theories alongside both classical and current research areas. To assist in learning, each chapter includes a brief introductory summary and a closing overview of the chapter's key points. Each chapter also provides a list of recommended readings with brief annotations. Designed to be suitable for use in both seminars and lectures, as well as for independent study, we hope the book serves as a valuable resource.

1 Source: The Guardian, https://www.theguardian.com/environment/2024/oct/14/nature-carbon-sink-collapse-global-heating-models-emissions-targets-evidence-aoe, accessed on 31.10.2024.

We extend our gratitude to our colleagues at the Department of Technology, Risk and Environment at the University of Stuttgart and the Center for Interdisciplinary Risk and Innovation Research at the University of Stuttgart (ZIRIUS) for their insightful discussions and constructive feedback. We are grateful to work in such an inspiring environment! We thank the student assistants Hanna Sophie Mast, Lukas Günsch, Lena Ebersbach and Amelie Dresel for their invaluable help with proofreading and formatting both the German and English versions of the book. Our thanks also go to Alexander Hutzel, Eva Lang and Fabiola Valeri of Nomos Publishing for their assistance with the publication.

Munich/Stuttgart, October 2024

Cited literature:

Richardson, K., W. Steffen, W. Lucht, J. Bendtsen, S.E. Cornell, J.F. Donges et al., 2023: Earth beyond six of nine planetary boundaries. Science advances, 9 (37): eadh2458.

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Chapter 1: Introduction – The social recognition of environmental problems

Overview

In this chapter, you will learn about the issues and questions that environmental sociology seeks to tackle, as well as the difficulties associated with them. You will become familiar with realism and social constructivism, the two basic epistemological positions from which fundamentally different approaches to environmental sociology are derived and which are therefore hotly debated. Of course, you will also gain an impression of the importance of climate change, global environmental change and their consequences for society in sociology.

Every single day, the social subsystems of politics, the economy, science and civil society are confronted with the issues and consequences of global environmental change and climate change. Environmental science has long shown that the ways in which we manage our economies and live today are not sustainable. The damage, risks, and unintended side effects that our way of life causes, for example, in the form of carbon dioxide emissions, soil degradation, species extinction, and resource depletion, make fundamental change a necessity (Richardson et al. 2023). Despite this, all subsystems are dominated by a no longer carefree yet strangely unwavering adherence to unsustainable goals, routines, and structures (Blühdorn 2022). The Canadian environmental sociologist *Raymond Murphy* (2015) sees the causes of this societal inability to find adequate responses to the global environmental catastrophe in the reaction patterns with which societies ignore transformation necessities. Since their economic and supply concepts are dependent on fossil infrastructures, they construct path-dependent "normalities" either by denying the problems or through technocratic optimism about solutions ("*wishful thinking*"). Thus, the magnitude and complexity of the necessary change seem to be mirrored in the behavioural rigidity that opposes it. This makes it all the more urgent to understand society-nature relations, and the conditions that enable them to function and change. These are precisely the kinds of questions environmental sociology seeks to investigate. This textbook aims to introduce this field of research, familiarise readers with the most important theories, and enable them to understand the social aspects of the geological era known as the Anthropocene, the (white) man-made modern era (Crutzen 2002).

This introductory chapter has three goals: We will define the subject matter of environmental sociology, outline the emergence of the field of research related to it, and look at the major challenges on which environmental sociology must take a position. These three goals cannot be pursued separately, because the determination of the subject matter, the approach, and the tasks are closely interrelated: they are mutually dependent on one another. The need to deal with mutual influences and effects (*interactions and interdependencies*) can be considered constitutive for environmental sociology as well as the sociology of technology. This is demonstrated in the following discussion about the subject matter and development of environmental sociology. We continue paying attention to categorical interactions throughout the rest of the book in order to understand the

interdependencies between "environment" and "society" and to demonstrate their significance in environmental sociology.

1. Environment and nature as objects of scientific observation

The way humans gain knowledge about "the environment" (*epistemology*), and the intensity with which they shape and change the so-called natural environments (*physics, biology*), are interdependent. Epistemologically, contemporary knowledge about the natural environment and the opportunities and risks associated with it comes primarily from systematic observations, experiments and simulations that are mostly scientific and technical. However, these observations, for example weather records or observations about plant growth and possibilities for increasing yields, are not 1:1 representations "of the world out there". Instead, they are influenced by societal interests and beliefs as well as by the instruments of observation (→ chap. 3 on society-nature relations, section 3 on relational theories of environmental sociology). For example, early weather records (which began in Germany in 1881) were mainly focused on locally significant major weather events and their consequences (storms, floods, dry seasons); in contrast, in contemporary meteorology, global contexts and long-term changes occupy a privileged position. Which weather data are generated depends on the interests that the data are intended to serve, such as interests in disaster management or productive agriculture. The type of data generated changes as new interests emerge and new technical instruments for data collection are developed, such as measuring stations and their locations. Therefore, the weather record only provides an imperfect and selective image of the terrestrial weather, according to whichever features are selected as relevant and the options available for observing them.

Epistemologically, two basic positions are used to evaluate environmental observations in environmental sociology (Rosa 1998; Dunlap 2010): realism and social constructivism. These will only be roughly sketched here. *Realists* assume that the basic structures of reality can in principle be reliably represented in (data-based) experience and can at least be described in a scientifically valid way: according to this position, meteorology provides a reliable image of the weather and climate. That is, realists assume that a biophysical world exists that is independent of human interpretation and that this world can (at least partially) be objectively grasped as such by humans. *Social constructivists,* on the other hand, emphasise that nature must always first be recognised linguistically, culturally and scientifically, and that all knowledge is therefore situated in cultural, technical, and social practices. They assume that the described realities (*ontologies*) also always carry within them the (historically and culturally diverse) perspectives from which their description arose. From a social constructivist perspective, the images that people make of nature and the environment to construct their reality are models embedded in socio-cultural presuppositions and rooted not least in the technologies that people have created in order to be able to observe, measure, and interpret their environment. What the world beyond these social descriptions is "really" like remains in principle inaccessible. From a social constructivist point of view, mete-

orology thus provides a description of weather and climate that also expresses the respective social interests, hopes and concerns as well as the instrumental possibilities of weather observation. Consequently, knowledge about nature and society depends on the underlying expectations, perceptual categories, and instruments of investigation. However social constructivists do not assume that knowledge about nature and society is intrinsically arbitrary or fundamentally "wrong", but rather that it is selective and embedded in the social and technical conditions of its production. Radical constructivism (Glasersfeld 1997) represents another perspective. Constructivists make a distinction between external reality and the human construction of reality, because every image of the world ultimately arises in the human sensory apparatus and is a construction of the brain, which processes the sensory impulses according to its own laws (*autopoietically*). Accordingly, radical constructivists assume that no "reality" exists independently of human interpretation; instead, the external counterpart always appears as a biological-mental construct. From the perspective of radical constructivism, truth or objectivity is not a question of conformity between external reality and internal reality, but of "viability", i.e., the usability of the constructed images for further action and decision-making.

Social constructivism or "moderate constructivism" can be seen as a compromise in the realism-constructivism debate, in which the emergence and interpretation of knowledge is conceived as socio-technically mediated and socially constructed. Murphy describes this position as "constructionist realism" as follows: "Humans socially construct their conceptions and practices (including those concerning nature and risk), as well as technologies, according to their culture and power. They are not, however, pure discursive spirits in a material vacuum, but instead embodied beings embedded in a biophysical world" (Murphy 2004: 252). This position provides a fruitful epistemological basis for environmental sociology and interdisciplinary cooperation with the natural and technical sciences, without pushing the critical potential and genuine epistemological interests of sociology too far into the background. Accordingly, "moderate constructivism" is the basic epistemological position on which this book is essentially based (exception: relational approaches in chap. 3 on society-nature relations).

2. Environment and nature as objects of social appropriation

From a sociological perspective, the descriptions of climate and nature—and thus also our understanding of them—change because our methods and interests change. At the same time, climate and nature are themselves dynamic and our understanding of the way they work is used to shape them according to human needs and expectations, or to reshape and "appropriate" them. Talk of the social, or capitalist, "appropriation" of nature comes from economic theory and, since the analysis of capitalist societies in political economy, has been accompanied by a view that the alienation of labour is also an alienation from nature, whereby nature is reduced to a (usually privatised) means for the purposes of human existence (Moore 2015). Thus, nature is not seen as having any intrinsic value; instead, "unprocessed nature" as an extra-societal presence only acquires value

when it contributes to private property formation or to the creation of social value, for example, as fertile soil for the farmer or as a generative principle in biotechnology. Here and in the following, we generally understand the social appropriation of nature to mean the fact that, at the latest since the emergence of industrial societies, nature exists only as "socialised nature", because its manifestation reflects the various social modes of appropriation of earlier societies. These can be economic forms of nature appropriation, but they also include the forms of appropriation seen in global tourism or nature conservation, which likewise serve human purposes.

The social appropriation of nature changes our perception of nature, because nature and the climate then do not exist as pre-human primary nature, but as socially reshaped (appropriated) and globally "warmed" secondary nature. To stay with this example: Weather and plant growth change within the context of climatic fluctuations and through interactions with each other. In addition, humans influence weather and plant growth intentionally, based on their knowledge and interests, and also unintentionally. For example, cloud seeder aeroplanes alter the amount, type and location of precipitation by "seeding" clouds with mixtures of silver iodide and acetone to protect agriculture. Genetically modified crops are introduced to gain higher yields or better resilience to climate change. At the same time, they sometimes result in unintended changes, such as outcrossing in neighbouring plants. Both measures thus change the effects and the perception of climate and nature.

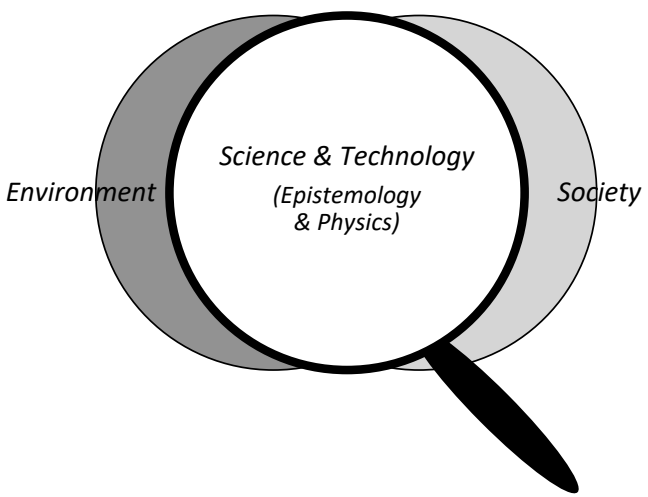

Figure 1: Environment and society understood through a scientific/technical lens; source: own illustration

Environment, or what we call and perceive as "environment", and society, likewise a social construct, can therefore only be studied *sociologically* by taking into account the epistemological contexts in which they are described and the

socio-material contexts in which they change. In addition to specialised global change sciences, biology (the science of living beings) and physics (the science of the fundamental phenomena of nature, its properties and laws) provide analyses of the inner workings and effects of the environment and also take into account interactions between matter and energy in space and time. Textbooks on environmental sociology must always consider the scientific/technical mediation of society-nature relations, which is represented in Figure 1 as a magnifying glass of knowledge and influence. This textbook was therefore designed so that all chapters take into consideration the scientific/technical levels of mediation and their epistemological and bio-physical conditions.

3. Environment and nature as subjects of environmental sociology

This brings us to the heart of the current difficulties: All societies are urgently seeking answers to the manifold threats posed by global warming, ocean acidification, species extinction, and other unintended side effects of technological progress. If, for example, our relationship with nature is to be deliberately redesigned through transformations in the energy, agricultural, and transport industries, then environmental sociology should direct its attention to both a) the societal perception and evaluation of the underlying problems, goals, and approaches for solving problems, as well as b) the organisation of the respective relationships with nature and their spatially and temporally given conditions (→ chap. 3 on society-nature relations). This can be done, for example, in the context of sociological analyses of scientific climate descriptions, individual environmental attitudes, collective consumption patterns, political decision-making processes, or environmental laws. The studies then concentrate on the societal handling of problematised natural conditions ("social nature"); the biophysical interactions between nature and society remain excluded.

However, there is a dispute within the discipline about what the contribution of sociology should be: For some, it should be limited to the sociological study of perceptual processes and the conditions of social action and inaction. Others argue that sociologists should use their knowledge of social change to investigate ongoing and necessary processes of socio-ecological transformation and to intervene regarding the shaping of those processes. In the second perspective, it is not possible to develop this field of investigation—which now encompasses environmental problems, the perception of those problems and approaches for overcoming them—without simultaneously engaging with scientific and technical approaches. Therefore, inter- and transdisciplinary[2] cooperation with the technical and natural sciences and with relevant societal actors outside science is unavoidable (→ chap. 10 on transdisciplinarity). Ultimately, any societal engagement with the internal and external nature of people, i.e., with their bodies and the physical-material environments of their actions, is shaped by technologies and

2 The term transdisciplinarity describes a research approach in which several scientific disciplines work together and incorporate input from non-academic actors (e.g., from public administration, civil society, or business) to develop knowledge about real-world problems and their possible solutions (Brandt et al. 2013; Jahn et al. 2012).

their context-specific use. Since the Stone Age, people living in various forms of cultural organisation have used a wide variety of technologies not only to depict and reflect on natural processes, but also to use and modify them to their advantage. The nature of these technologies shapes the sociological understanding of the respective societies so fundamentally that they are described, for example, as agrarian or industrial societies.

Science and technology and the organised forms in which they are used thus fundamentally mediate society-nature relations. Whenever there is talk of species extinction and climate change or of energy and mobility transitions, sociologists are always dealing with a field of investigation in which other experts (for example from the fields of climate research, engineering sciences, and political offices) have a superordinate claim to knowledge. That is, their expert descriptions of the problems and possible solutions are seen as higher ranking or more valuable. Given this situation, sociology can either focus its research interests on the emergence, meaning, and impact of these descriptions, such as the descriptions of climate change, or take these descriptions as a starting point for their investigations into the consequences within society, such as climate discourses, policies, and risks, or take them up as a point of reference for the exploration of society's possible modes of reaction to individual climate protection measures or the "Great Transformation" (WBGU 2011; Gross & Mautz 2015). Thus, sociologists sometimes investigate the scientific diagnoses of environmental change, which are usually controversial, sometimes they look at the societal consequences of those diagnoses, and sometimes they explore the spaces available in society for reacting to the diagnoses.

Sociology, like the historical sciences, finds it difficult to realistically regard the diagnoses presented by other disciplines (e.g., climate knowledge) as an unquestioned starting point. After all, one of sociology's basic insights is that perceptions, problem discourses, and forms of reaction are shaped by societal influences such as cultural values and political interests—and that this applies equally to the world of science (Mannheim 2013 [1929]; Luhmann 1993). If sociology takes a social constructivist approach to the diagnoses, it can show the extent to which climate knowledge is part of the social construction of reality (Berger & Luckmann 1991 [1966]), but from this perspective it is not possible to formulate legitimate proposals for action, nor does it succeed in grasping the context of the problems "behind" their social thematisation. Instead, society-nature relations and environmental problems get lost in the social communication about them. In the realist approach, environmental sociology thus appears as a "society-blind" auxiliary discipline that is limited to studying the social acceptance for measures taken in response to authoritative diagnoses, without being able to consider the social embeddedness of these diagnoses and measures. Thus, the power relations, disparate interests, and typical perceptual distortions in the scientific and political handling of environmental problems and the development of measures, which sociologists feel responsible for exposing, remain hidden. Conversely, in the constructivist approach, environmental sociology appears as a "reality-blind" single discipline that produces analyses of the various expert and lay assessments of

nature, technology and environmental problems, but which is not able to join other disciplines in the search for solutions to environmental problems. Thus, crises in nature-society relations, including those that potentially threaten societal and human survival, remain hidden from the very science designed to investigate societies.

4. Theoretical perspectives of environmental sociology

How, then, can and should environmental change and possible social modes of reaction be researched in sociology, if either the respective diagnosis must be regarded as a social construct, which differs nationally, historically and disciplinarily from the interpretations under other conditions (sociology of knowledge), or if, conversely, we ignore the social conditions in which the problem is interpreted and possible solutions are formulated (positivist)? From the point of view of "moderate constructivism", for this question it is important to examine the categories, patterns and structures through which society perceives the natural environment and how it interacts with it. For this investigation, environmental sociology provides answers within the framework of two different paradigms: In the first, more social constructivist paradigm, the focus is on society's perception of nature external to society, and also on the reconstruction of its meaning within society (→ chap. 2 on the social construction of nature). The focus is on the role that nature discourses and perceptions play in society, and their effect on ideas about how society can respond to the ecological crisis.

In contrast, the second approach focuses more strongly on the interactions, interdependencies, and intermingling between nature and society (→ section 3 on nature-society relations). This perspective explicitly addresses the problem that not only the analysis of and talk about environmental problems takes place *in* society and is shaped by its structures, but that society, beyond discourse and representation, is also physically and materially involved in the production and reproduction of nature, the environment, and environmental problems to an appreciable extent. There is no longer any primary nature on Earth in the sense that it exists independently of human actions and activity. Even the large nature conservation areas depend on human-made laws, are affected by emissions, and are analysed and mapped by scientists. The American historian of science Donna Haraway views the current state of terrestrial nature (among other things) as a plantation in which anthropogenic processes interacting and intra-acting with other processes and species have produced planetary effects (Haraway 2016; → sections on Donna Haraway in chap. 3 on nature-society relations).

The term Anthropocene thus refers to the fact that humans have become the main influencing factor in the history of nature and the Earth: There are many indications that humans have irrevocably changed the planet and its climate. In the third chapter, we therefore devote ourselves in detail to such theoretical approaches, which are becoming more and more prevalent in the sociological consideration of environmental problems. Their focus goes beyond realism and social constructivism and lies on nature and technology as historical products of specific

interactions and assemblages. Figure 2 shows a diachronic perspective on the left, i.e., the temporal development of the progressive penetration and entanglement of environments and societies, while on the right a synchronic perspective is shown, i.e., a snapshot of the present moment, with the diversity of different natural relationships that exist concurrently.

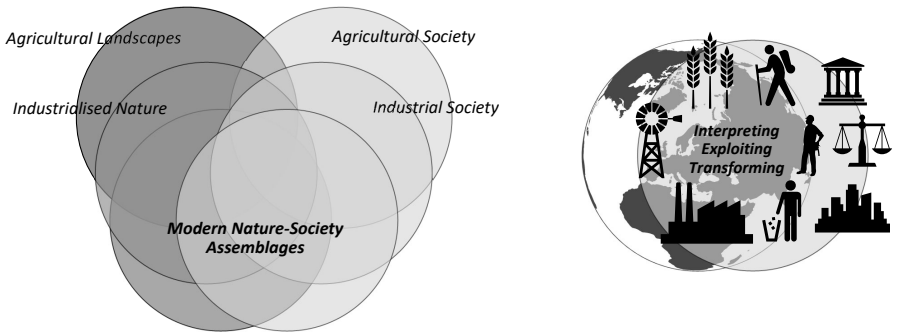

Figure 2: Societies and their environments, diachronic development and synchronic diversity; source: own illustration

Environmental sociology determines how different and unequal social relationships with nature are, how social groups—institutionalised at different levels—interact with natural and technical entities and thereby produce increasingly unstable "assemblages", i.e., hybrid networks of heterogeneous, human and non-human elements, such as cities with their institutions, actors, infrastructures, resource consumption, etc. (Latour 2005, → sections on Bruno Latour in chap. 3 on society-nature relations).

5. The development of environmental sociology

Entirely in the sense of Max Weber and Alfred Schütz, environmental sociology firstly includes any individually and/or collectively meaningful thinking and acting that is directed towards the biological, ecological, energetic, material and technical goals of social action, which are colloquially referred to as body, nature, environment and technology. The focus is thus on all matters of concern that arise less through the immediate research object ("environment"), but through references to social lifeworlds that are always already pre-interpreted by thinking and acting people (Schütz & Luckmann 1980). In addition to meaningful thinking and acting oriented towards the phenomena of body, nature, environment and technology, environmental sociology also examines the structures and problem areas that arise as direct and indirect (often unintended) side-effects of this thinking and acting, or which arise as their unconscious crystallisation at the meta-level, for example, the risks of industrial production processes (→ chap. 5 on risk) or the routines and infrastructures of a highly mobile society (→ chap. 9 on infrastructures) whose future viability is in question. The focus is thus on the interactions of societies or different social groups with their natural and technical

environments, their progressive interpenetration and the resulting sustainability problems. These sustainability challenges in particular and the questioning of the continued validity of leading convictions in science, politics and society have led to the fact that a large part of environmental sociology critically examines social structures and technically and economically formulated necessities. In this respect, environmental sociology is also a critical social science with an interest in transformation processes (→ chap. 8 on innovations and transformation processes).

Compared to other sociological fields of work, environmental sociology has a relatively short history. It began in the United States and Western Europe as a reaction to the early environmental movement and as an approach for examining the undesirable consequences of growth and progress. The first authors, who are exclusively white men, were primarily concerned with applying a sociological perspective to address environmental problems that were only just starting to garner public attention. At the core of the discipline, this request was met with rejection: it seemed to contradict Durkheim's programmatic rule of sociological method (explaining social facts by social facts) and instead open the door to biological and technical reductionisms, thus relegating to the background the forces of social development judged to be more significant, such as differentiation and rationalisation (Kropp 2002: 29– 47). If we look at the emergence of environmental sociology in the turbulent 1970s, we can clearly see the extent to which its subject matter challenges traditional sociological thinking. After 20 tough years of struggle, William Catton and Riley Dunlap, two American pioneers of environmental sociology, laconically summarise the discipline's problematic tradition: "The Durkheimian legacy suggested that the physical environment should be ignored, while the Weberian legacy suggested that it could be ignored, for it was deemed unimportant in social life." (Dunlap & Catton 1994: 14).

Sociology was founded at the time of industrialisation and developed as a theory of modern industrial society, hence it also unwittingly adopted an industrialised worldview. In it, "emancipation from nature"—understood as overcoming natural hazards and natural scarcities—plays a central role, especially in relation to expectations of social progress.

An implicit concept of nature, however, entered into all sociological publications, whereby nature usually forms, at least semantically, the opposite or antithesis to society, culture, and technology, so that conceptual reflection on nature is at the same time a reflection on society (Soper 1995). For Karl Marx, who paid fundamental attention to the metabolism between humanity and nature as a productive force, the social "realm of freedom actually begins only where labour which is determined by necessity and mundane considerations ceases" (Marx 1998 [1894]: 807) – that is, when the constraints imposed by "first nature" (the laws of nature) and bourgeois society as "second nature" are overcome. Emile Durkheim, in contrast, reconstructed the "social facts and things" with reference to their significance in the formation of social order. He was interested in natural and technical phenomena exclusively in relation to their function for social coexistence. Max Horkheimer and Theodor Adorno were among the first to address the unseen repercussions of humans' increasing domination of nature. In 1947,

in their "Dialectic of Enlightenment" (Horkheimer & Adorno 2002 [1947]), they criticise the enforcement of one-sided instrumental reason, arguing that such an approach turns the mastery of nature into the starting point for the domination of internal and external nature. As a consequence, subjects become incapable of recognising the strangeness and diversity of nature; rather, instrumental reason leads to a positivism of the factual and ultimately turns against civilisation itself.

Ulrich Beck takes up this reflexivity, with which technological progress, rationalisation, and differentiation as linear ideals of modern societies turn into a politically, economically, and ecologically threatened "risk society" (→ chap. 5 on risk). With his ground-breaking book "Risk society. Towards a new modernity" (1992, in German: 1986), he documented a fundamental shift in perspective in sociology: the market economy and industrial society had long ceased to be regarded as perennial success stories and were instead viewed as institutionally overburdened in dealing with self-produced risks and side effects. Beck's analysis appeared shortly after the reactor accident in Chernobyl and in the very same year as Niklas Luhmann's "Ecological Communication" (1989, in German: 1986) and, towards the end of the 20th century, influenced a generation of sociologists who were increasingly concerned with the environment, technology and risk in society.

Leading social theorists, such as Anthony Giddens (2009), Zygmunt Bauman (2011), Bruno Latour (1993; 2017), and John Urry (2011), also discussed environmental issues from a sociological perspective and consider how ecological risks and societal responses should be addressed in the discipline. The new focus on environmental issues has been triggered primarily by the growing international attention on (threatened) external nature and the changes it is undergoing (*global environmental change*), as well as the consideration of those threats and changes on the political agenda and in large parts of society, and thus in most areas of study in sociology (Lidskog et al. 2015: 342).

Where interest continued to be lacking, major research funding bodies responded to the public's environmental concerns and helped by setting specific topics for investigation and calling for more interdisciplinary and internationally integrated research. Subsequently, environmental sociology acquired legitimacy even outside the sociological tradition through international collaboration with neighbouring disciplines and the natural sciences. In this context, theoretical perspectives that do not assume an a priori distinction and distinctiveness between nature, technology, and society are becoming more important, particularly in Science and Technology Studies. Such perspectives instead point to interactions and the permanent production of socio-technical hybrids (→ chap. 3 on society-nature relations). Nevertheless, a rather realist perspective on the environment still dominates in US environmental sociology, whereby the environment is at least partly seen as a biophysically determined reality. Since, from this perspective, the environment sets clear and identifiable limits to social development, many American researchers accept that they are dependent on the interpretations and calculations of the natural sciences for their work. In contrast, European environmental sociology, while not doubting the existence of this reality, focuses on its perception and interpretation in environmental debates and social practices in predominantly social construc-

tivist terms, and also critically reconstructs statements and analyses produced by the natural sciences. Rolf Lidskog, Arthur Mol and Peter Oosterveer (2015: 349) also observe that representatives of American environmental sociology are mostly critical of growth and engaged in environmental politics, while their European colleagues tended to critically examine and question environmental political engagement. In fact, much of environmental sociology is still strongly influenced—and in some cases paralysed—by ongoing realism-constructivism debates about the meaning of the interactions between nature and society as well as technology and society and the related epistemological issues.

6. The challenges facing environmental sociology in the Anthropocene

We have deliberately used the concept of the Anthropocene during this introduction, even though it has been heavily criticised from a social science perspective. This concept was brought into the discussion by atmospheric chemist and Nobel laureate Paul Crutzen in his highly regarded *Nature* article "Geology of mankind" (2002). In it, Crutzen warns of the ominous effects and long-term consequences of growing human influence on the environment and climate, and advocates for an "appropriate response at all levels", including major geoengineering projects for "climate optimisation" (ibid. p. 23). While he points out that only a quarter of the world's population is responsible for the environmental changes whose effects first and foremost threaten the other three quarters of the population, as a natural scientist he does not address the underlying inequalities and differences behind this relationship between the polluters and those affected.

More problematically, he is also insensitive to the worldviews and ways of acting that led to this situation, such as the unswerving belief that all problems can be solved using technology, on behalf of all humanity, by those who caused them, and without moving away from the structures that are driving the problems. These "structures", according to a variety of critiques, include an unleashed market economy that some authors call the "Capitalocene" (Bonneuil & Fressoz 2016; Haraway 2016; Moore 2017), oil-hungry democracies whose stability depends on growth and imperial exploitation (Mitchell 2011; Brand & Wissen 2017), and major infrastructure and utility systems whose sustainable transformation is at risk of failing due to technical, economic, and discursive path dependencies (Unruh 2002), as chapter 9 illustrates using energy and mobility transformations as examples. Further critiques of the Anthropocene concept include its anthropocentric focus on human-only concerns that overlooks the suffering of other creatures, the industry-fixated blindness to the long and diverse history (including, e.g., bacterial history) that led us to the Anthropocene, the unwavering belief in progress, and the invalid ethnocentric generalisation of the perception of the problem and ideas for possible solutions. Finally, the term is usually used unilaterally to focus on climate change, while other environmental problems that are occurring independently of climate change are hardly considered, such as the eradication of most living creatures (euphemistically called "species extinction"), the poisoning of soils and food, and the threats posed by nuclear waste, mono-

cultures, and resource depletion. These are some of the great challenges facing environmental sociology today.

There are considerable and sociologically challenging paradoxes associated with these challenges, which we explore in chapters 4 on environmental awareness and 5 on risk. To date, environmental threats have been least problematised by those who are most affected by them. Environmental awareness is evidently dependent on one's material prosperity—prosperity which in turn is contributing to the problems. Conversely, the most environmentally conscious segments of the population are regularly characterised by particularly environmentally damaging behaviour. As the German Environment Agency's Environmental Awareness Study from 2019 shows, the lifestyles of these population segments tend to involve heavy use of mobility, land and goods, making their resource consumption and emissions higher in almost all areas than those of social groups who take little interest in environmental issues. As a result, at both the household and national levels, the amount of climate-relevant emissions produced is a reliable indicator of prosperity. In particular, the lifestyle of the middle classes, which is the most aspired to globally and which is rapidly increasing especially in cities, is accompanied (despite the advantages of urban density) by an oversized ecological impact that must be overcome. However, technologies aimed at overcoming this and which promise to decouple productivity and resource consumption (such as energy-saving appliances and digital monitoring of resource flows) are often overcompensated by so-called rebound effects and provide financial, psychological and technological motivation for even higher consumption (Sonnberger & Gross 2018). All this makes it increasingly clear that quantitative prosperity is not compatible with the qualitative requirements of living well together within Earth's planetary boundaries (Richardson et al. 2023; WBGU 2011, 2016).

As the publicist Naomi Klein (2015) and the philosopher Bruno Latour (2018) point out particularly succinctly, however, in affluent Western societies economic constraints appear greater and more urgent in the short term than ecological problems and the questions of long-term survival associated with them. But if the previous productivity and growth-oriented guiding principles are called into question in the face of impending environmental catastrophes and a lack of success in overcoming them, the central tenets of scientific and political thinking will lose their validity (Latour 1996). This is why the field of transformative research was established in the new millennium, which we will present in the last chapter. It addresses the 21st century's key question on a wide variety of levels, namely, how can societies develop in a way that preserves the vital foundations they need to survive and thrive?

The size and complexity of the issue suggest there will be sufficient research potential in this field for the coming decades. In this context, it will be important to overcome the above-mentioned realism-constructivism gap in favour of investigations into sustainable transformation processes and their feasibility. To achieve this, environmental sociology will have to deal with conflicts and social movements (as it did during its emergence in the 1970s and 1980s): a field of research that we will discuss in chapter 6. While in some places it seems that

researchers consider it part of their duty to take a critical "counter-hegemonic" look at the dominance of neoliberal perspectives (Lidskog et al. 2015: 350), other sociologists are often reluctant to position themselves politically. They avoid proximity to environmental movements and political activists who have managed to have put ecological issues on the agenda. For all researchers in environmental sociology, the challenge is to operate in a highly politicised field of research, to be aware of the situatedness of one's own research perspectives, and yet to meet the demands of scientific quality criteria, without which science becomes obsolete.

In addition, there is another problem: In view of the global environmental problems and institutions, environmental sociology can only to a certain extent limit itself to the study of local, regional and national environmental problems, conflicts and measures. It must take global contexts and connections into account, in all their economic, political, and biophysical dimensions. Against this background, too, environmental sociology faces the difficulty of not only being confronted with (normative) questions of justice and fairness, but also with their various context-dependant formulations. Inter- and transdisciplinarity therefore characterise their working methods and increase the demands on their research, methods and the communication of their results. It is necessary to "realistically" take into account the scientific analyses of environmental and technological risks and to keep a "socially constructivist" eye on their situatedness and dependence on societal values and work perspectives, while at the same time looking beyond the academic horizon and "pragmatically" integrating the problem perceptions and proposed solutions which do not catch scientists' attention but which substantially shape the course of the environmental debate. In our view, in the face of these challenges, environmental sociology must neither barricade itself in an ivory tower nor lose itself in the melange of political actions. In many cases, it will therefore amount to a critical-constructive "public sociology" (Buroway 2005) that is connected to international and interdisciplinary networks and reflexively makes its disciplinarily well-anchored findings available to broad publics in aid of the necessary changes.

What students can take away from this chapter:

- Knowledge about nature and the environment as objects of interpretation and observation
- An insight into the fundamental tension between realist and social constructivist approaches in environmental sociology
- An understanding of the relationship between environmental sociology and other sciences that deal with environmental issues (especially the natural sciences and engineering)
- An understanding of the current challenges in environmental sociology in the face of global ecological challenges (Anthropocene)

Recommended reading

Beck, U., 1992: Risk society: Towards a new modernity. London: Sage Publications. *A classic of environmental sociology. It is still recommended today, because it unpacks the basic problem of what the ecological crisis means for modern society.*

Bonneuil, C. & J.-B. Fressoz, 2016: The shock of the anthropocene. *An introduction to the Anthropocene from a social theoretical perspective: these two historians raise awareness about the socioeconomic, socio-technical, and political backgrounds of unsustainable natural conditions.*

Latour, B., 1993: We have never been modern. *An important polemic of environmental sociology: What, so the question goes, if sociology as a whole, with the distinction between society and nature, would give in to a modernist self-deception as the source of ecological problems?*

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Chapter 2: The social construction of nature and the environment

Overview

In this chapter, you will learn about the diversity of social ideas about nature (concepts of nature) and their significance for social order. You will learn that social constructions of nature are anchored in everyday knowledge on a basic level but are also differentiated according to the logic of different subsystems. At the same time, you will gain insights into the role played by different constructions of nature in relation to historical changes and for dealing with the challenges of sustainable development.

People perceive nature and the environment through a cultural lens that directs their gaze and determines their associations, preferences and fears. As a result, they experience the natural world (everything from the external environment to their own bodies) not "directly" but rather from whichever perspective is socially available to them. It is known, for example, that children initially adopt the views of their parents and perceive arachnids either as threatening or useful, depending on their parents' view. On a supra-individual level, social groups value what fairy tales, the media and fellow humans portray as beautiful about nature and, conversely, fear what is seen as threatening within their culture or social milieu (e.g., dark forests or big bad wolves). In everyday constructions of nature, rabbits, dogs, meadows, lakes, and enzymes regularly fare better than pigs, wolves, forests, rivers, and bacteria. Such symbolic categories go hand in hand with far-reaching consequences, so that, for example, pigs, which are not inferior to dogs in terms of their sensitivity and intelligence, are perceived in many countries primarily as "farm animals" for industrial meat production, the presence or absence of wolves plunges entire regions into conflict, and rivers are easily politicised in relation to usage rights (→ chap. 6 on the environmental movement and environmental conflicts). German understandings of nature, for example, differ from those of other countries and continents due to different nature discourses and references to nature, but even within Germany, perceptions of nature differ from group to group depending on factors such as expertise, practical relevance and interests, as studies on nature awareness show (→ chap. 4 on environmental attitudes and action).

Professional and specialised knowledge influences the perception and evaluation of nature, in that certain phenomena from the biophysical world receive special cognitive attention. Take for instance the differing ways in which a forest ranger and someone going for a walk may view forest damage, or the way body weight is typically viewed from female and male perspectives. Normatively, different functionalities and values are attributed to natural things. In addition, individual and collective practices have a fundamental influence on the perception of nature, because they enable relationships with nature and experiences of nature and turn them into routines, so that dog owners or gardeners, for example, perceive dogs and plants differently and interact with them differently than people with only little practical experience with dogs or plants. This is also expressed by the fact that it is these individual and collective practices that enable people to

adapt to the natural world and organise it according to their own interests. In this respect, interests determine what is perceived as nature in the first place and which possibilities for interaction and utilitarian considerations are included in people's actions and decisions. The social significance of the environment is therefore generally anthropocentric: the environment only becomes an issue and a problem when its otherwise taken-for-granted availability and usability for human interests is called into question or when natural disasters thwart human interests. By contrast, ecocentric constructions of nature are dealt with almost exclusively in areas like the ethics or philosophy of nature and have recently received increasing attention in cultural and human geography as "more-than-human-worlds" (→ chap. 3 on society-nature relations).

For environmental sociology, the socio-cultural representations of nature in everyday knowledge (as well as their temporal and social variability and contextual character) are an important field of investigation, especially in interdisciplinary contexts. For example, when urban development decisions need to be made about green infrastructure such as gardens and parks (Priego et al. 2008), when acceptance among rural communities must be gained for the proposed locations of wind turbines or production facilities, or when it is necessary to increase motivation for sustainable consumption, social scientists are asked about patterns in the way nature is perceived and evaluated. We will take a closer look at the background and analysis of environmental attitudes and environmental awareness in chapter 4, and environmental conflicts are covered in chapter 6.

In contrast, this chapter discusses sociological theories that focus on social *constructions* of nature and their importance for social order and social change. Here, "constructions of nature" encompasses all the ideas and interpretations of nature that are directed towards external "nature" or the natural environment (the latter being commonly associated with environmental problems). The theorisation of constructions of nature has only been pursued intermittently in sociology. On the one hand, this is the consequence of a disciplinary division of labour, through which social metabolism and its social observation, i.e., the "socio-material" relationships with nature, have long been considered the object of study of the natural sciences—even though their importance for ownership structures and the relations of production was highlighted early on by John Locke and Karl Marx (Immler 1985). On the other hand, social constructions and discourses about nature have often entered contemporary diagnostic theories as a subtopic, for example in critical theory (Horkheimer & Adorno 2002 [1947]), cultural theory (Douglas & Wildavsky 1982), systems theory (Luhmann 1989), and the theory of reflexive modernisation (Beck 1992). In light of this, the theoretical references to *social constructions of nature and the environment* in environmental sociology are somewhat disparate and need to be systematised for presentation in this book. We do this by first reconstructing the history of the social construction of nature from a sociology of knowledge and thus social constructivist perspective, before addressing the social transformations in the way nature is understood in historical perspectives of appropriation. We then explore the relevance of these constructions of nature for the challenges of sustainable development in the so-called

"Anthropocene". Then in chapter 3 we embed the social construction of nature described here within interdependent socio-material relationships with nature and build on these ideas to look at *society-nature relations*.

1. The social construction of nature: the importance of concepts of nature in everyday knowledge

After Peter Berger and Thomas Luckmann (1991 [1966]) highlighted the importance of everyday knowledge for social meaning, social action, and social institutions, a social constructivist perspective became established in the social sciences that is interested in the conditions that lead to the social production of what counts as knowledge about reality. According to this perspective, actors acquire knowledge that is established in their culture through processes of primary and secondary socialisation, for example, about what they should eat, what they should think about certain animal species, how they think about forests and forest management, or how they evaluate their bodies. Accordingly, (environmental) sociology considers knowledge and thinking about nature as an object of study that is deemed "universally valid" by the various actors in a society, but which cannot be objectively determined. This also applies to the natural sciences: the expert view of natural scientists is also shaped by institutionalised perspectives of knowledge and by historically and culturally embedded specialised knowledge and routines. "Nature" thus emerges within the framework of "the social construction of reality", according to the title of Berger and Luckmann's (1991 [1966]) central work. Accordingly, while instinct plays a minor role in how people navigate their way in the world, we are primarily guided by our everyday cultural knowledge, which we internalise during the process of socialisation through language, symbols, roles, and routinely applied value judgements. After we adopt our initial constructions of nature as intersubjectively valid realities from significant others such as parents and teachers, and subsequently regard pigs and cows as useful sources of food, and dogs and cats as lovable pets[3], this is followed by role-specific technical and specialised knowledge. It comprises correspondingly differentiated norms, which are conveyed to us in subworlds such as agriculture, medicine, cuisine and art, so that we develop different constructions of nature and routines, for example, in relation to pigs (pork). As long as we do not experience crises or other external disruptive processes that challenge our culturally ingrained understandings of nature and subject their plausible validity to a recoding that "resocialises" us, then those constructions will guide our social action over the long term. In this way, constructions of nature stabilise the social order as an intersubjectively shared, taken-for-granted reality.

The language we use, or one could also say the usual *way* of speaking about nature, the environment, and the body, becomes fundamentally important as the origin of the social construction of the everyday world. It structures semantic fields of reference to nature (for example, city and country, farm animal and

3 In recent years, critical animal studies have critiqued the hierarchical ordering and unequal treatment of animals as specialism and explored possibilities for thinking in "multispecies worlds" (Westerlaken 2020).

domestic animal), organises individual experiences according to vocabulary into generalised orders of meaning, and provides the inventory of knowledge that determines what is considered "normal" in the various subworlds – at least until it is no longer possible to easily act and interact with other people on the basis of the stable constructions of nature found in everyday knowledge. Thus, constructions of nature guide everyday actions like a social institution that creates the "mental rules of the game shared standards and a semiotic environment of mutual predictability. Institutionally, therefore, a pork steak on the menu is unproblematic in many Western countries, but a dog steak would cause irritation. If, however, industrial meat production with its mostly cruel conditions for pigs and cows is scandalised in the social world and becomes unbearable for the individual, this triggers a legitimation crisis of the dominant construction of nature and can lead individually, but also among specific milieus or even historically, to a change in the social construction of farm animals and to the creation of new subworlds, such as vegetarianism. However, the degree of reification or "objectification" of given worlds of meaning in strong institutions (which have been bolstered through many repetitions, norms and rules) plays a major role and limits their variability. It can be assumed that the social understanding of nature as an essential part of social worldviews is strongly objectified, firmly integrated into the social inventory of knowledge and therefore very stable. It is virtually regarded as "natural" or inevitable.

This strong institutionalisation of constructions of nature can be traced back to the fact that in societies those fields of action that solve everyday problems (such as the provision of nutrition) are primarily institutionalised. The institutionalised handling of such solutions, which transcend time and place and are common to all members of society, is so profoundly culturally internalised that their institutionalisation is regarded not as subjective but as objective reality, and is passed on from generation to generation. As a result, cognitive dissonance can occur: Individuals integrate contradictory attitudes into their social practice, such as an assessment of farm animals' living conditions as intolerable on the one hand, and the culturally routinised consumption of meat on the other. In contrast, countercultural constructions of nature, such as a vegan lifestyle, are perceived as "alien" and rejected by the bearers of the "ingrained" patterns of interpretation. Dialectically, the "externalisation" of the dominant interpretations as a self-evident, religiously, culturally and legally secured, "objective" inventory of knowledge in most relevant structures of society contributes to this: "The reified world is, by definition, a dehumanized world," write Berger and Luckmann (1991 [1966]: 106), emphasising that humans experience this world as a "facticity", an "*opus alienum*" over which they have no control.

The nature of society thus emerges in everyday life, as a socially shared reality becomes institutionally entrenched through individual educational processes and social interactions and is passed on in a variety of ways in subworlds of meaning. This social construction of nature is objectified and, according to the final paragraph in Berger and Luckmann's seminal work, has an effect on the appropriation of nature:

> "Man is biologically predestined to construct and to inhabit a world with others. This world becomes for him the dominant and definite reality. Its limits are set by nature, but, once constructed, this world acts back upon nature. In the dialectic between nature and the socially constructed world the human organism itself is transformed. In this same dialectic man produces reality and thereby produces himself." (Berger & Luckmann 1991 [1966]: 204).

This dialectic in relation to nature—i.e., the internal construction of biophysical phenomena as "external nature" and their externalised objectification—plays a central role in environmental sociology. Modern everyday knowledge is determined by a nature-society dichotomy that simultaneously enables the demarcation between society and nature *and* their continuous, primarily technical production and transformation for the benefit of social needs—a double movement that Bruno Latour (1993) calls the modern constitution (→ sections on Bruno Latour in chap. 3 on society-nature relations).

Since antiquity, nature has conceptually denoted the other – the thriving being (*phýsis*) in contrast to the technically made (*techné*). As externally given, non-human, and extra-societal, this concept of nature consolidates the special position of humans as "extra-natural": living (and thus natural) humans do not understand themselves as such, but as cultural beings that rise above nature. Helmut Plessner (2019 [1965]) accordingly coined the category of an "excentric positionality". According to this, humans are positioned or "placed" in their environment, but in this environment they are dependent on language, culture, and knowledge for the objectification of themselves and the external world. Thus, unlike other living creatures, humans do not orient themselves instinctively in their surroundings, but do so by entering into a distanced, "open-minded" relationship with their natural environment and themselves. "As an excentrically organized being, the human must *make himself into what he already is*" (2019 [1965]: 287, emphasis in original). This "law of natural artificiality" means that, for example, the environmental question not only presupposes human beings' "excentric positionality" —how they distance themselves from nature—but that engagement with the environmental question is what first makes people human beings with this special ability in the first place. In his philosophical anthropology, Plessner thus develops a non-dualistic understanding of humans and nature, which seems to contradict the social distinction between nature and society. But even the opposition of nature and society, conceived in everyday practice, is conceptually already a dialectical reciprocative relationship.

The dialectic of the construction of nature is also remarkable in terms of its significance for collective identities. The demarcated other, nature, defines and stabilises the identity of the demarcating subject – even in human-human relationships. Thus, gender relations and ethnic concepts of race can be examined as sub-themes of social constructions of nature. Starting from the white, Western man as the imagined norm, women were—and still are—identified with reference to their "natural weaknesses" or "reproductive tasks" as the Other (*caregiver*)

in opposition to the male homo faber (*breadwinner*). In the same way, in ethnic classification schemes, the white identity only emerges through demarcation from people of other colours, and the Global South as an imagined counterpart to modern society. In each case, these demarcations are based on the assumed closeness to nature of the respective group, while civilisation took the place of the sacred as the counter-concept to nature (Luhmann 1989: 3). In the aforementioned cases, the subject—society, the (white) man, modernity—is constituted through the negation of the objectified Other, above which the subject rises.

From a semiotic perspective, 'nature' can fundamentally only be addressed and signified if it can be positioned as something else within our worlds of language and signs. However, when collective identities are 'shifted' in postmodern deconstruction through the dissolution of dualistic essentialisms, it appears, according to Stuart Hall, as if those identities are no more than wandering signifiers "in search of a *transcendental signified*" (1989: 12)[4]. Clearly, the signifier is just as impossible to pin down as the signified. Just as there is no essential, ontological approach to intrinsically distinguish *people of colour* from white populations, the conceptual identification of nature also fails to provide a substantial determination of itself or its essentialist (i.e., intrinsic) differentiation from the artificial, the human, or the social. As a result, "nature" remains a complementary concept used for differentiation from the non-natural and which is primarily brought into the debate when one wishes to pull ultimate justifications out of one's sleeve to counter the desired, the made, and the conceivable through a stark contrast with the original, the self-evident, the necessary. There may be, in addition to a conservative use of the concept, also progressive ones with which alternatives are brought into play by positioning the existing as not 'natural' and drawing on extra-societal nature as a template for other, natural orders, as witnessed in Romanticism and in the environmental movement.

These considerations make clear that the concept of nature is used according to social interests and patterns of interpretation. However, it does not only exist "abstractly" in everyday knowledge and social ideas – it is structurally anchored in worldviews, from where it informs motives for action and practices. For cultural anthropologist Mary Douglas and political scientist Aaron Wildavsky (1982), different social groups' constructions of nature express their respective group loyalty and their different beliefs in the necessity of hierarchical norms and rules. Accordingly, market-oriented and individualist milieus with strongly liberal attitudes "select" an understanding of nature as benign, resilient and capable of supporting their lifestyles, whereas members of the environmental movement, with its emphasis on strong group cohesion and egalitarian models of interaction, prefer the idea of nature as vulnerable (→ chap. 4 on environmental attitudes and action).

4 In semiotics, a sign (for example, a symbol or word) consists of a signifier (for example, ♀ or "woman") and a signified (the concept denoted by the signifier, for example female / feminine / woman).

2. "Nature" in systems theory: environmental communication in social subsystems

Niklas Luhmann (1989) takes a somewhat different approach and examines communication about nature and environmental problems in the various social subsystems from a systems theory perspective. In order to answer the question of whether modern society is able to adapt to ecological threats or whether it will enter a discursive standstill in the dispute over different constructions of nature, he sheds light on how ecological problems are communicated in a function-specific way and the associated possibilities of perceiving relevant environmental changes. When he talks about the environment, Luhmann usually does not mean "external nature" as a system on its own (however this may be defined), but rather "as the totality of external circumstances, it is whatever restricts the randomness of the morphogenesis of the system and exposes it to evolutionary selection" (Luhmann 1989: 6). This thus includes everything that does not belong to the social system, everything that is suppressed as background noise in favour of the communicative reduction of complexity.

For Luhmann, societies are social systems whose elements are not individuals but self-referential (*autopoietic*) operations in the form of operationally meaningful, i.e., resonant communications. Luhmann defines communication as a combination (unity) of three selection processes (information, message and understanding), through which social systems differentiate, reproduce and maintain themselves. This takes place in communicative operations that use subsystem-specific codes and associated programmes, which help the respective system to restrict its overly complex environment to the information that is relevant for its own processing by means of limited and categorically preformed selections. This means that communication is only possible if it can be continued in subsystem-specific "codes" that the system uses to differentiate itself from external environments.

This means, for example, that in the legal system and in the economic system different information about nature is selected, communicated and understood, and the respective communicative operations cannot be exchanged across system boundaries either. Instead, the messages must correspond to the differentiated and evolving programmes in such a way that further operations can refer to them in a subsystem-specific, self-referential process, for example, within the economic system. In the economic system's central code "payment/non-payment", external "environment" only occurs as a resource (e.g., pork) that yields benefits for economic processes of production and consumption. This means that for meaningful communication to take place, ecological issues must be communicated as quantity and benefit calculations that can be economically internalised (Luhmann 1989: 58). In the subsequent steps involved in the selective processing of information, a decision is then made in a subsystem-specific way as to whether or not it is economically rational within the framework of existing programmes to make payments for ecological benefit calculations, for example to invest in better living conditions for livestock. According to Luhmann, the subsystem's ability to respond to ecological criticisms of pig farming is correspondingly limited: "whatever does not work economically, does not work economically" (1989: 62).

Analogous to the theory of differentiation, the legal system is not orientated towards the language of prices, but towards the language of norms, so that here the assessment of meat production takes place according to the code of legal/illegal and follows the corresponding programming in laws, ordinances or statutes. In the legal system, too, ecological criticism of the environmentally harmful consequences of intensive pig farming, for example, only disturbs the smooth fulfilment of familiar expectations if it triggers conflicts within society against which legal precautions must be taken for the sake of social order. However, the development of programmes that would grant pigs rights against society is not only unlikely, but also not compatible against the background of existing case law, so that Luhmann expects an "essential incongruence of legal categorisation" in relation to environmental problems (1989: 68).

According to Luhmann, the differentiation of society into subsystems with their respective specific information processing represent the conditions under which ecological facts and changes in nature can generate "resonance", according to systems theory:

> "It should be noted that this is a phenomenon that is exclusively internal to society. It is not a matter of blatantly objective facts, for example, that oil supplies are decreasing, that the temperature of rivers is increasing, that forests are being defoliated or that the skies and the seas are polluted. All this may or may not be the case. But as physical, chemical or biological facts they create no social resonance as long as they are not the subject of communication. Fish or humans may die because swimming in the seas and rivers has become unhealthy. The oil pumps may run dry and the average climatic temperatures may rise or fall. As long as this is not the subject of communication it has no social effect. Society is an environmentally sensitive (open) but operatively closed system. Its sole mode of observation is communication." (Luhmann 1989: 28f.).

A system "can only see what it can see. It cannot see what it cannot. Moreover, it cannot see that it cannot see this" (Luhmann 1989: 23), so it remains unperturbed by anything that may be happening outside its self-referential perception. Luhmann sees this structural blindness as the reason why modern societies find it so difficult to react to the ecological threats facing them. The theoretical approach of viewing societies as self-referential systems that reproduce themselves through communication led him to the logical conclusion that social systems and their *autopoiesis* can only be jeopardised through communication. Although he considered the ecological problem to be a threat to society, the basic idea of functional differentiation means that modern societies without a control centre only ever process events in their self-referential, system-specific codes (i.e., environmental disasters or the increased scientific communication about them) according to their own modes of operation in a way that creates resonance within the system. Even if irritations arise in individual subsystems, for example when the scientific uproar about climate change, which is judged to be "true" within the system, reaches the political system through communicative interdependencies, society as a unit

of differentiated subsystems produces too little resonance (and indeed too little unified resonance) or too much and "the system can burst apart from internal demands without being destroyed from outside" (1989: 116).

It would be wrong to assume that Luhmann does not see any relationship between societies and their natural environments. He does consider social systems to be "environmentally sensitive" and energetically dependent, for example, and discusses the possibility of self-endangerment in the sense of a destructive evolution, at the end of which humanity would disappear. But despite this "structural coupling", social systems remain too "operationally closed" to be environmentally open. This means that "at the level of the system's own operations there is no ingress to the environment, and environmental systems are just as little able take part in the autopoietic processes of an operationally closed system" (Luhmann 2012: 49). Thus, operational closure does not mean thermodynamic or energetic closure, but rather the exclusively recursive enabling of intrasystem operations through the results of their own communication, so that social systems are autonomous in Luhmann's sense, but not self-sufficient.

The concept of structural coupling reveals Luhmann's own understanding of nature, which is strongly influenced by the cybernetics of his time and especially by the work of the biologist Humberto Maturana (Kropp 2002: 92). Consequently, structural couplings limit the range of possible structure formation within which a system can organise its *autopoiesis* and through which its existence is already adapted to the (respective natural and social) environment. Where functionalism conceptualises social functions and their fulfilment (e.g., adaptation to the natural environment) as inputs or outputs, Luhmann thinks of the material and energy-related system prerequisites as structural couplings whose complexity can only be understood through the internal complexity of the social system. For Luhmann, the operational closure, within which the conditions of nature remain opaque to societies, guarantees the environmental openness of the system, because the relationship with the environment is not determined by the environment, but by the system's closed mode of organisation: "The entire physical world, including the physical basis of communication itself can affect communication only via *operationally closed* brains, and these brains only through *operationally closed* consciousness systems, and thus only through 'individuals'" (Luhmann 2012 [1984]: 63, emphasis in original). With this understanding, Luhmann draws on contemporary scientific concepts of nature: he analyses societies not in the sense of Emile Durkheim as reality *sui generis*, but in terms of the biologically described ability of living organisms to re-produce and organise themselves, above all with a focus on *autopoiesis* and the possibilities of cognition that this provides. Biological laws shape his understanding of the social construction of reality. We should not underestimate Luhmann's great achievement: the analysis of the inevitably subsystem-specific communications, problem definitions and constructions of the natural environment and their significance for political ecological communication. Yet ironically, this is accompanied by the fact that he naturalises and sets absolute conditions for this analysis.

3. Changes in the social construction of nature

In contrast, the following outline of changes in the social construction of nature is concerned with analysing the historical rules of construction according to which society's understanding of nature is formed. Like Luhmann, the sociologist Emile Durkheim tried to show in his sociology of religion (1912) that concepts of nature and classification systems (for example, totemism) are not taken from nature, but originate in society and are projected onto nature. According to his research, social concepts and classifications of nature organise nature according to the same (hierarchical) patterns that already exist in society. The repercussions of this once again make visible the dialectical architecture of the concept of nature mentioned above; these projections help to stabilise social relations through analogies with nature (Durkheim 1995 [1912]: 221ff.). Durkheim thus ascribes a legitimising and reproductive function to constructions of nature for existing social relations and emphasises their historical and ideological character.

Because society's concepts of social order are linked to those of nature, from a sociological perspective it is worth looking at concepts of nature, their changing history and their significance for society-nature relations. The focus here is on the extent to which constructions of nature are linked to ideas of society and social order, and which practices of ordering and stratification they legitimise, reproduce, exclude, strengthen or devalue. In the following, we will outline some moments of the history of the concept of nature and its interrelationship with social change. This interdependence between the concept of nature and society's self-image also applies to the sciences themselves: In the sciences, too, there are competing understandings of the natural environment and, for example, its resilience, depending on the underlying hypotheses about society's metabolism with nature. This is also true for sociology.

Carolyn Merchant (1980) describes the connection between the understanding of society and the understanding of nature very pointedly in the context of her project to uncover analogous changes in the description of nature, the industrial/technical treatment of nature and gender relations:

> "As Western culture became increasingly mechanized in the 1600s, the female Earth and the virgin earth spirit were subdued by the machine. The change in controlling imagery was directly related to changes in human attitudes and behavior towards the earth. Whereas the nurturing earth image can be viewed as a cultural constraint restricting the types of socially and morally sanctioned human actions allowable with respect to the earth, the new images of mastery and domination functioned as cultural sanctions for the denudation of nature" (Merchant 1980: 2).

According to Merchant's hypothesis, the establishment of a mechanistic view of nature—which began in the modern era and conceptualised nature as a machine that functions according to laws—is the cultural prerequisite for more profound interventions in the natural environment. Such interventions would not have been morally legitimate and acceptable in conditions with holistic constructions

of "nature" as a good "mother" or overarching "cosmos". Raymond Williams takes this thesis to its logical conclusion with regard to the "unacknowledged key concepts" of Western thought in the modern understanding of nature: "Men come to project on to nature their own unacknowledged activities and consequences" (1980: 81). According to Williams, one of the most important changes since the 13th century is the loss of a plural, polyphonic construction of nature and the associated marginalisation of alternative patterns of legitimation and explanation, through which an authoritative understanding has gained interpretative sovereignty. Since the end of the Middle Ages, the term "natures" has been replaced by the singular "nature". In the context of this singularisation, nature was first described as a goddess, then as a divine mother, an absolute monarch, a minister, a lawmaker and finally as a selective breeder, thus opening up different spaces for the interpretation of nature-society relations. The second essential change concerned the construction of a "state of nature", which preceded the human state and had to be subjugated by civilised society, whereby the state of nature and civilised society became opposites.

The template for this dualising European thinking, which draws a distinction between a determined nature and a society of free people, was provided by ideas such as the *scala naturae*, the ladder of nature, which emerged in Ancient Greece and placed every living being, from the lowest to the highest, in hierarchical order. At first, it was not humans at the top but rather supernatural beings, from the angelic hierarchy to the deity. Later the leading position was essentially taken by the white man. Even though the theory of evolution has long since rendered this idea obsolete, many considerations of long-term human development are implicitly linked to it, for example when it is said that the human animal has taken the lead in evolution and left its natural state through civilisation. Although humans and nature, environment and society have been conceived in a variety of ways in historical and cultural comparisons (Descola & Palsson 1996) and essentially can hardly be distinguished from one another, the idea of a complementary, recognisable nature has prevailed over time and continues to shape the self-image of modern societies and their claim to dominate nature, above all through technology.

The high point of this dualistic opposition between nature and society was reached in the 19th century in industrialising societies. Nature was now completely degraded to a realm of enslavement and struggle, and had to be subjugated and controlled. Modernity and progress, according to the corresponding understanding of the world, were, in contrast, valorised through the concept of "mastery of nature" and regarded as universal processes of civilisation. This conceptual juxtaposition of a controllable nature and freely developing societies led to the utilisation, exploitation and devaluation of nature and the environment to an unbelievable extent, which today appears intolerable and threatening and calls the future of civilisation into question. In his book "The Conquest of Nature", historian David Blackbourn (2007) uses the example of German hydraulic engineering to explain how the external environment has been systematically and fundamentally remodelled and appropriated since the 18th century. He illustrates how

cultural intentions and ideas of a progressive conquest of nature by humans led to the draining of wetlands, the straightening of rivers, the construction of dykes and dams, thus creating heroic subjects and also triggering a countermovement, the romantic glorification of the natural. Blackbourn traces this objectifying thinking about nature from the domestic "colonization" (ibid. 153) of the high moors to the Nazi seizure of the "wild East" and its inhabitants:

> "What made the 'wild East' wild? [...] the inhospitable environment [...]. In this distorted view of the world the indigenous inhabitants were written off as 'history-less people', not true Europeans, 'nomads' rather than tillers of the soil. And the Germans projected onto them the qualities to be expected of wild people or 'savages': passivity, a childlike nature, above all cunning, cruelty, and undying hatred for the 'superior race'. They cast them, in short, as Indians." (Blackbourn 2007: 301).

William Cronon (1992) reconstructs a similar devaluation of the rural in favour of the process of urbanisation. He uses the context of the opposing but interdependent development of modern metropolises (Chicago) on the one hand and a rural "hinterland" (The Great West) on the other. Cronon argues that industrialisation and the emergence of capitalist markets brought about the first widespread transformation from a "first" (natural) nature to a "second" (human-made) nature. The urbanisation of industrial society required a supply network between consumer households in cities, industrial production facilities, the agricultural hinterland and the markets, in which the natural materials (e.g., forests) and the variety of agricultural products (e.g., *pigs*) were standardised into tradeable goods in capitalistically organised supply chains (e.g., wood or *pork*).

At the beginning of the 20th century, Max Weber defined "cities" as those (ideal or model) places in which the population can only satisfy its everyday needs with products that are "acquired or produced specifically for sale on the market" (Weber 1968 [1921: 1213). Accordingly, key characteristics of urban consumer households are that they are unable to survive without being supplied by the private market and public infrastructure, and that more reproductive (mostly female) housework takes place in them than productive (gainful) labour. This urban lifestyle has become the norm since the mid-20th century. It first alienated urban populations from the natural conditions of their existence and has since been based on the promise of an industrial society freed from natural constraints, scarcity and tight social control. From the outset, this social order has been associated with the ecological problem of rapidly increasing energy, land and material consumption. However, overcoming this problem and thus moving towards sustainable development paths is still blocked today by internalised ideas about the progressive growth, convenience and consumption opportunities provided by industrial production and consumption methods—and these ideas have long since extended beyond urban areas to the rural population of the Global North. In the meantime, this way of life, now described as "imperial", has emerged as a central element of a growth paradigm based on economic land grabbing that is

ecologically, socially, and economically destroying the natural foundations of life in the Global South as well (Brand & Wissen 2021).

A brief look at the historical development of the interplay between the understandings of nature and society shows that the social construction of nature varies depending on society's internal conception of the social appropriation of nature: An understanding of nature is not formed independently of the appropriation of nature—it is a necessary prerequisite. For this reason, in recent decades concepts that no longer focus on the social constructivist understanding of nature but rather on the co-production of constructions and relationships with nature have gained importance in environmental sociology, and this has been accompanied by a particular interest in the role of the technical sciences (→ chap. 3 on society-nature relations). For the understanding of nature in the natural sciences such as physics, biology and chemistry, this means that their scientific practices, which are based on the worldview of the Enlightenment, also presuppose the objectification of nature as a counterpart to society, whose laws must be deciphered and utilised (→ chap. 1 introduction). In the course of the development of scientific technologies and industrial forms of production, new ways of appropriating nature and the opening up of new habitats in particular have shaped scientists' understanding of nature. For sociology's understanding of nature, this in turn means that, as a child of industrial society, it adopted the worldview of the natural sciences and thus either completely ignored "nature" or viewed it as a passive resource and product of social development (Kropp 2002: 37). Agrarian societies would have formulated a different type of sociology based on their different understanding of cyclical nature. For this reason, the current question, discussed in the last section, is whether the global environmental catastrophe will lead to a different understanding of nature and a different sociology in post-industrial knowledge societies.

4. Social understandings of nature, sustainable development and the Anthropocene

Considerations about how "nature" could be included in theories of social change were only developed later and were mainly due to pressure generated by an awareness of the ecological self-endangerment of modern risk societies (Beck 1992). Bruno Latour has described the systematic ignoring and denial of dependence on nature as a "Modern Constitution" (1993) and took it as the starting point for a new sociology (2005) that is devoted to the manifold associations beyond the juxtaposition of nature and society (→ sections on Bruno Latour in chap. 3 on society-nature relations). The disregard for socio-natural relations that became established alongside the modern concept of nature enabled modern societies and their sciences to formulate a paradigm of growth and progress as if industrial mass production, location-independent mass consumption, and the associated global consumption of resources and waste were possible on the basis of optimised mechanisation and social organisation without risky, catastrophic repercussions for the natural environment and the embeddedness of people in terrestrial contexts. In contrast, a new sociology should place the interactions and

repercussions between plural "natures" and "societies" at the centre of the study of social change. For today it no longer seems likely that the Earth, as a finite planet, can support an ever-expanding world of production and consumption without suffering irreparable damage as a place where people live (Richardson et al. 2023). The task at hand is to explore the understanding of nature in the geological epoch of the "Anthropocene", in which human activity has become the main driver of bio-physical conditions.

The majority of society-nature relations that this has produced are proving to be unsustainable: From a global perspective, so many resources are being consumed, so many emissions and waste products are being produced that are harmful to health and the environment, so many species are being wiped out, and there is so much interference in ecosystems that it is foreseeable that future generations will no longer be able to fulfil their existential needs, and entire regions and population groups are already threatened by global climate and environmental change. Has this dramatic development led to a different understanding of nature? Not really. It is true that a growing number of people worldwide consider climate change, the loss of biodiversity and environmental degradation to be an important or even the most important policy area. However, beyond individual approaches and specific concepts, this has not yet been accompanied by a culturally new understanding of nature in everyday social knowledge and the relevant subsystems, in the context of which the interrelationships between nature, technology and society would be reinterpreted. Rather, the dominance of objectifying constructions of nature can be seen right down to the concepts that will supposedly bring about a socio-ecological transformation and create a sustainable society. They continue to ignore the dependence of humans on nature and fail to adequately recognise the entanglement of human practices with non-human practices, ecological effects and repercussions. Symptomatic of this is the three-pillar model of sustainability, which dominates the debate and is often criticised in concepts of sustainable development, but is always considered more "feasible" than so-called "strong" ecological guard rail models. Although this recognises the challenge of integrating ecological, social and economic concerns, it remains insufficiently complex in relation to their interdependence, monitors targets by separating them into different areas (and indicators), and almost completely ignores the natural anchoring of social and economic systems. In contrast, the 17 *Sustainable Development Goals (SDGs)* adopted by the United Nations in 2016 manage to overcome the sectoral juxtaposition of economic, social and ecological issues by naming thematic priorities and sustainability goals in addition to universal human rights. However, the *SDGs* also read like an anthropocentric wish list of what is worth preserving, without even slightly revising the industrial-capitalist perspective of the appropriation and control of nature or its cognitive foundations.

And yet this understanding of nature has long since led to ecological changes on a planetary scale. Accordingly, many (geo)scientists refer to our geological era as the Anthropocene to argue that humans have become the greatest influencing factor on the biological, geological and climatic conditions of life on Earth. Due to the unintended repercussions of human intervention, the planet has left the

relatively stable phase of the Holocene. In this analysis, nuclear fallout and plastic particles are regarded as "index fossils" that indicate the problematic human activity which, thousands of years from now, will still be associated with the militarised, industrial-capitalist way of life and its understanding of nature. The term "Anthropocene" gained attention primarily through the widely acclaimed article "Geology of Mankind", in which meteorologist and Nobel laureate Paul Crutzen (2002) problematises the variety and depth of human interventions in ecological contexts and their risky consequences. As a consequence of this development, which Crutzen blames on the wealthy quarter of humanity, he now sees that science and technology's enormous task is "to guide society towards environmentally sustainable management [..]. This will require appropriate human behaviour at all scales, and may well involve internationally accepted, large-scale geo-engineering projects, for instance to 'optimize' climate" (Crutzen 2002: 23). Many social scientists, especially those working in the field of political ecology (see, e.g., Swyngedouw 2006), criticise this conclusion. It perpetuates the industrial understanding of a passive nature to be technologically managed and optimised through scientific-technical mastery over nature, which is responsible for precisely those forms of nature appropriation that are seen as the cause of global climate and environmental change. In particular, simplistic and naturalising talk of the Anthropocene attracts harsh criticism because it either abbreviates or completely ignores the economic, (geo)political and social background and effects of environmental degradation with its winners and losers.

In contrast, historians Christophe Bonneuil and Jean-Baptiste Fressoz (2016) elaborate in detail how various regimes of nature, particularly unsustainable forms of energy use, militarisation, the formation of profit-oriented technostructures and fossil capitalism, consumer society and the handling of knowledge and non-knowledge all contributed to the Anthropocene in historically, culturally, and economically very unequal ways. In relation to the present, Timothy Luke (2020) therefore views Anthropocene concepts as a political strategy for interpreting threatening anthropogenic changes. The term "anthropogenic" falsely attributes these changes to humanity as a whole, although they are largely caused by privileged groups in rich countries who use specific technological, political, financial and cultural means and mystify them as scientific enlightenment. The benefit of the Anthropocene concept for these groups is that it enables them to position themselves as "planetary managers" and impose immense burdens on the "managed" human and non-human actors, legitimised by their scientific and technical authority. The Anthropocene concept thus repeats the specific constructions of nature elaborated in the previous sections, not only for the unrestrained subjugation and conquest of non-human creatures and environments, but also for the degradation of a section of humanity.

The claim has been made that "humanity" is now "enlightened" about the ecological problem and, thanks to better knowledge and new scientific and technical instruments, is in a position to make progress towards a solution, yet it becomes clear that even that claim still exists within the traditional dualistic understanding of nature as an objectified counterpart that can be controlled by advanced

societies. The relationship between the concept of nature and the scope for social development that it opens up remains the blind spot of social constructions of nature.

5. The social construction of nature and its political implications

The environmental sociological considerations of the first three sections of this chapter can be summarised in the three findings that social constructions of nature are firstly shaped by different perspectives of perception depending on practices, knowledge and appropriation interests, which are secondly deeply anchored in everyday knowledge and subsystem-specific resonances, and thirdly are externalised and materialised in modes of appropriation that correspond to historically and culturally specific understandings of nature. In this respect, the social construction of nature has a dialectical character because, as generalised and institutionalised ideas about appropriate and inappropriate ways of dealing with nature, it creates social imaginaries of what is desirable and feasible, what is permitted and forbidden (→ chap. 3 on society-nature relations). It symbolically structures the material and energy-related exchange relationships and directs them into historically and culturally varying forms of use. Constructions of nature prove to be the mostly unacknowledged flipside of society's understanding of itself. They reveal more about society and its organisation than about socio-ecological relationships, and are shaped to no small extent by laboratory instruments and production techniques and the scientific/technical interpretations which these enable. Nevertheless, modern constructions of nature have become controversial, with the result that different interpretations and assessments compete in every environmental debate. Even supposedly objective expert knowledge appears to be "biased" and permeated by implicit theoretical assumptions and specific interests and values, as we explain in chapter 6 on environmental conflicts.

Conversely, constructions of nature prove to be political terms, as Luke (2020) recently highlighted in relation to concepts of the Anthropocene. Such terms always implicitly project and postulate a social order, with unequal effects for men and women, urban and rural areas, low-, middle- and high-income countries, as well as the various non-human creatures and regional landscapes. For this reason, concepts of nature are essential elements of the social power relations that encompass human-human, human-technology and human-nature relationships (Kropp 2002). Against this backdrop, Donna Haraway (2018) calls on us to no longer place (male) humans and their destructive activities at the centre of history, but rather the diverse ways of living demonstrated by other species ("critters") in order to find out what survival in *sympoiesis* might look like on the damaged planet. For more on this see chapter 3 (society-nature relations).

What students can take away from this chapter:

- Knowledge about patterns in the way nature is perceived
- Knowledge about historical shifts in the social constructions of nature
- An understanding of how nature is conceptualised in different sociological theoretical traditions
- An understanding of the relationship between social constructions of nature and the social order
- An understanding of the political nature of social constructions of nature

Recommended reading

Berger, P.L. & T. Luckmann, 1991 [1966]: The social construction of reality. A treatise in the sociology of knowledge. *An introduction to social constructivist thought. In this book you will learn about the fundamental importance of (everyday) knowledge for social institutions and society's self-image.*

Barry, J. 2007: Environment and social theory. *An equally recommended introduction to social ways of conceptualising the environment from ancient and pre-modern times to contemporary industrial societies.*

Luhmann, N., 1989: Ecological communication. *A classic of environmental sociology. This book provides a good insight into how the ecological question is discussed in systems theory.*

Blackbourn, D., 2007: The conquest of nature. Water, landscape and the making of modern Germany. *A conceptual perspective on the interdependence of anthropogenic landscape transformation and processes of industrial modernisation. This book illustrates the consequences of constructions of nature in landscape planning and societal development.*

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Chapter 3: Theories of society-nature relations

Overview

In this chapter, you will learn about sociological theories that are used for studying the variability of and changes in society-nature relations. You will learn that dialectical approaches, which do not contrast nature and humans/society in a dualistic way, but do distinguish them dichotomously, are criticised by relational theories in which this distinction is itself an object of study and is held responsible for ecological problems. Here, too, it becomes clear that "knowledge about nature" cannot simply be taken for granted in environmental sociology.

When someone says "I'm in a relationship", we know that the person is talking about a (still) unresolved relationship that probably does not conform to the institutionally standardised model of a marital partnership, may be temporary and is "unusual" in one way or another. This relationship will leave its mark on the future lives of those involved, it can also affect their social environments and goes beyond a purely platonic exchange of ideas. Thus, significant repercussions, side effects and interactions are to be expected. We recommend keeping this relational image with its successively unfolding consequences in mind for the following considerations on the messy society-nature relations. It can help to think about the unresolved connections and exchange relationships that not only lie outside social norms, but that even go beyond the way in which these norms can be thought and spoken about.

Constructions of nature provide the symbolic-discursive, one could also say cultural and implicitly normative basis of our *relations* with nature (→ chap. 2 on the social construction of nature). At the conclusion of our discussion on these social constructions of nature, we therefore stated that they always imply social instructions for action and should therefore be regarded as proto- or "knowledge-political" concepts (Kropp 2002): "Knowledge-political" means that the underlying knowledge is accompanied by political consequences, i.e., that supposedly neutral knowledge about nature itself has political effects. It favours certain approaches to evaluation and action, legitimises the domination of nature and classifies everything that is subordinated to human purposes as "natural". References to "naturalness" or "the nature of things" project and justify a social order that involves, for example, unequal options related to identity and agency for humans and animals, men and women, urban and rural areas or people in the Global North and Global South. As we summarised, constructions of nature are part of social power relations, the implications of which extend into everyday life and working environments. Our current relations to nature and many practical forms of nature appropriation are proving to be an unsustainable exploitation and utilisation of resources, ecosystem services, fertility, etc. and are producing few winners and many losers (Bonneuil & Fressoz 2016; Haraway 2016; Robbins 2019).

Representatives of relational sociological approaches, on the other hand, are calling for the rejection of modern industrial constructions of nature and the un-

sustainable society-nature relations legitimised by it, in order to achieve climate-friendly, environmentally and socially just development. Relational approaches problematise the underlying knowledge and bring to the fore the diverse and unexplained forms of interweaving, interaction and mixing (hybridisation) that were addressed with the image of the "relationship". From their perspective, relationships with nature appear as relational, diverse and ambiguous, embedded in the respective contexts of their emergence, interpretation and actualisation. Thus, relationships with domestic animals differ from those with livestock, and different relationships with nature are typically found in conventional and organic farming, based on their mutually exclusive worldviews. These examples are a reminder that there are disputes about our relationships with nature and the "right" or "legitimate" way of dealing with the non-human world, because every reference to nature is framed by socio-cultural worldviews and overarching, moralised patterns of interpretation.

If one assumes the plurality and hybridity of society-nature relations, which are therefore variable and evolve in the context of cultural as well as scientific/technical possibilities, it follows that society-nature relations can in principle be shaped. The idea that there is only one possible relationship that is predetermined by "nature" or the natural sciences then becomes recognisable as a social fiction that imposes order. Just as marriage describes a possible institutionally fixed relationship between two people, whereby the diversity of other relationship possibilities is socially limited, the industrial society's relationship to nature (which is oriented towards the instrumental use of nature) has arisen historically, is institutionally anchored and marginalises possible alternatives. However, the consequences of the environmental destruction legitimised by this, such as global warming and species extinction, are increasingly causing it to be called into question. The critique is often formulated from the perspective of the theories of knowledge and science, since the dispute about the "right" relationship with nature is essentially about questioning the underlying epistemology and its knowledge practices (Haraway 2013; Latour 2005).

In this chapter, we look at various theories about our relationship with nature. They are all based on the assumption that biophysical conditions and social practices, interpretations and ways of thinking are interwoven. While dialectical approaches continue to distinguish, at least analytically, between the natural and social spheres, relational theories abandon this distinction, instead considering them as empirically endpoints resulting from imposed practices of purification. In the following, we first present dialectical and then relational approaches in order to explore the theoretical possibilities and thus also make alternative relationships with nature conceivable. To do so, we will first discuss the concept of "nature relations" in general and its inherited anchoring in dualistic thought. Then, in section 2, we discuss how this dualistic thinking is dealt with in dialectical approaches, and in section 3, we discuss the conditions for conceptualising nature relations beyond the dichotomous distinction between nature and society in relational approaches.

1. Nature relations – a look at the modern dualistic perspective on the relationships between human and non-human agents

The sociological concept of society-nature relations (in the plural) first addresses a variety of human-society-nature relations that involve not only social metabolism with nature but also other experiences and relationships with nature. They are expressed, for example, in agricultural nature relations such as livestock farming, in forms of urban development and the handling of green infrastructures, as well as in interactions with domestic animals, agricultural crops, ornamental plants, bacteria, viruses, one's own body, and so on. When talking about our relationship with nature (in the singular), the emphasis is not on the diversity of the connections between human and non-human living beings and biophysical conditions such as raw materials, sun, water, energy, etc., but on the dominant characterisation of human-society-nature relations through prevailing patterns of thought, institutional and legal norms and culturally entrenched practices. This dominant characterisation consists first and foremost of an instrumental and objectifying relationship with nature rooted in the idea of human exemptionalism, that is the belief that humans are exempt from ecological and natural constraints. Within this framework, "nature" is conceptualised in Western thought as an object of social action. The focus is on how nature can be cultivated and utilised, from the Old Testament *dominium terrae* (Genesis 1:28: "Be fruitful and multiply, and replenish the earth and subdue it, and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth.") to the Enlightenment writings of the English philosopher and jurist Francis Bacon (1561–1626), who asked about the possibilities of using knowledge to make nature subservient and suggested cataloguing it for this purpose, all the way through to current talk about nature as an "ecosystem service", gene pool or construction kit.

The prerequisite for this instrumental way of thinking about utilisation and subjugation is that nature is objectified as "the other": The opposition between nature and society, nature and technology, nature and art is the long-term result of social developments that began in Ancient Greece. Since the Enlightenment at the latest, this way of thinking is no longer conceptually "available", i.e., it can no longer be questioned because it is considered the only possible perspective. This view of nature has since had a "knowledge-political" effect in the form of modern epistemology (epistemology). Nature is thereby fundamentally opposed to the human and the social, is conceptually and epistemologically the other, the "non-identical", the self-acting (*physis*) with peculiar movements and laws that are fundamentally distinct from culture and technology. The strict distancing from this naturalness is a prerequisite for becoming human and in particular for the characteristic that is assumed to be unique to *homo sapiens*: "reason". In this way of thinking, the "human" realises their special position (Plessner 2019) when they learn to set themselves apart in order to mutate into a rational being, to discover and use nature as a counterpart, according to the corresponding basic features of Western philosophy (Böhme 1983). This opposition or contrast leads

to the "inescapable compulsion toward the social control of nature" (Horkheimer & Adorno 2002 [1947]: 27) and comes at a price:

> "Humanity had to inflict terrible injuries on itself before the self—the identical, purpose-directed, masculine character of human beings—was created, and something of this process is repeated in every childhood." (Horkheimer & Adorno 2002 [1947]: 26)

In the "Dialectic of Enlightenment", which was first published in 1947 in the face of the terrible atrocities committed by the Nazi regime, Max Horkheimer and Theodor W. Adorno (2002 [1947]) focus on the unintended repercussions of becoming human through the demarcation and objectification of nature: In this central work of critical theory, they shed light on how the mindset of instrumental rationality, which is deeply rooted in civilisation and focused on utilisation, led to the total appropriation of the object world and the cruel subjugation, exploitation and destruction of "other" people as well. This is where Donna Haraway comes in. With reference to the work of Maria Puig de la Bellacasa (2010), she discusses the "banality of evil" of the Nazi war criminal Adolf Eichmann, as analysed by Hannah Arendt, and remarks: "There was no way the world could become for Eichmann and his heirs—us?—a "*matter of care*". The result was active participation in genocide" (Haraway 2016: 36).

Only the differentiation and contrast of nature and society—or the context-specific contrast of nature versus culture, technology, art, people, and social practices—makes it possible to appropriate nature as an (external) "environment" and object. Nature, which humans are fundamentally a part of, appears from this perspective as a space or inventory that stands in opposition to human societies and which humans can appropriate, subjugate and use to satisfy their needs. In this dualistic epistemology, "rational human beings" and their works—namely culture, technology and society—are characterised precisely through their differentiation from a "nature" subject to laws and instincts, which is to be discovered, conquered, used, admired, subjugated and exploited. Any reflection on the relatedness to nature or the relationship to nature (in the singular) is consequently caught in a juxtaposition.

This epistemological dualism was widespread in sociology and can even be found in environmental sociology. In a reflected form, it also shapes current approaches for analysing society-nature relations and the related environmental problems, as we will explain in the first section of this chapter using the concepts of "societal relations to nature" (Becker & Jahn 2006; Becker et al. 2011) and "socio-ecological regimes" (Fischer-Kowalski 2011). However, these approaches no longer assume a fundamental dualism, but rather a dichotomy with two different sides. This is based on the assumption of an interactive interconnectedness with repercussions and interdependencies and the resulting dual character of society's relationships with nature (Brand 2014: 13). This dual character arises from the fact that practices of nature use—from food production to tourism—are always simultaneously shaped by cultural techniques, patterns of interpretation and institutional definitions on the one hand, and biophysical conditions on the other.

Due to this dual character, there are historically and culturally specific forms of interwoven material utilisation and cultural meaning creation: No meal is the sole result of *only* biophysical necessities and health requirements or *only* the creation of cultural meaning and socio-economic considerations. Rather, every eating style, like all other natural relations, inevitably has this interactive dual character. In the following illustration, we depict the area of interaction in society-nature relations as a grey overlapping area between the two spheres of nature and society, which are conceived as dichotomous. In it, biophysical structuring of natural classification is mixed with symbolic-discursive social determination. The biophysical structuring is theoretically attributed to material properties and their interaction. The symbolic-discursive structuring is explained on the basis of context-specific, culturally determined constructions of nature as well as the linguistic, respectively symbolic and discursive conditions of the relationship with nature and its perception (→ chap. 2 on the social construction of nature).

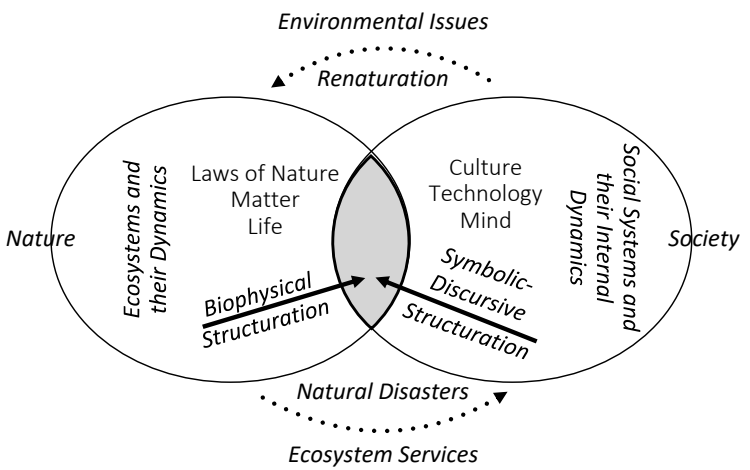

Figure 3: Interaction between society-nature relations in dialectical approaches; source: own illustration

Dialectical concepts are thus not strictly dualistic, but dichotomously structured. In them, the biophysical and energetic dynamics of ecosystems determine the sphere of nature beyond the area of interaction. From society's perspective, these are perceived as the "laws of nature" as well as the characteristics and peculiarities of matter and life, and are the subject of modern natural sciences. With regard to the social side, the conceptual starting point is the inherent laws of social systems, the social framework for interpretation and action provided by established institutions, influential discourses on the essence of nature and politico-economic power relations, which are reflected in cultural, technical and intellectual products and shape social practices related to how people deal with natural conditions. The investigation of this social side is the task of the humanities and social sciences. In dialectical concepts, the interactive mediation context is typically illuminated from two directions (shown as dotted lines in Figure 3). The first direction shows

the effects of society on nature – for example, through creating environmental problems (e.g., pollution) and solving environmental problems (e.g., renaturation or rewilding). The second direction shows the effects of nature on society – for example, in the form of socially relevant natural disasters, but above all as a source of ecosystem services for societies, such as food production and energy generation. In this context nature relations are primarily viewed from a functional perspective, in both directions. In contrast to relational perspectives, emotional or practical relationships play only a subordinate role beyond the dichotomously conceived interactions and the basic existential experiences of life (giving), ageing, illness and death. The insight into how much both natural disasters and social upheavals vary with natural-cultural conditions also comes rather short (cf. on this Beck & Kropp 2007).

Due to their functional orientation, dichotomous approaches are dominated by investigations into symbolic-discursive structuring and biophysical effects and repercussions, and how they are perceived and evaluated. Often a "purified" epistemological realism creeps back in with regard to the biophysical causes and effects, and a social constructivist view with regard to the symbolic-discursive structuring (→ chap. 1 on these epistemological perspectives). On their own, both perspectives are one-sided and based on the Cartesian dualism of the fundamental distinction between material things (*res extensa*) and mental phenomena (*res cogitans*). One criticism of epistemological dualism with regard to nature relations is that even in the natural sciences, findings are produced in socially determined cultures of knowledge and are thus semantically and discursively shaped (Knorr-Cetina 2013). Moreover, mental and cultural ideas do not arise independently of the biophysical forces that govern their development (Latour 1993). As we will see, Bruno Latour took up precisely this problematic separation into natural entities on the one hand and cultural or social phenomena on the other as a "modern constitution", which he said is responsible for the careless proliferation and interconnectedness of risky hybrid creations such as industrial agriculture, high-performance cows, nuclear energy, etc. (see section 3 of this chapter).

Bruno Latour and other representatives of relational approaches view climate change and species extinction—in other words, the deadly nature relations of the present—as a product of the far-reaching dualistic distinction between nature and society. From their point of view, it is precisely this wrong way of producing knowledge that leads to the ecological problems. If it were not assumed that (male) humans hold a special position and that their intellectual knowledge and cultural and technical abilities predominate the natural world, then, according to the ("knowledge-political") argument, human societies would appear as integrated components of ecological contexts that grow or die within those contexts and are therefore exposed to the diverse restrictions and repercussions of mutual relationships. The modern perspective of appropriation, however, with its knowledge practices, lifts *homo sapiens* out of their natural embeddedness in order to make this species the consequence-blind creator of new worlds according to its needs (instrumental exploitation).

In this epistemology, which has coagulated into our modern self-image, the world appears as a storehouse and humanity is legitimised to subjugate the cosmos and to use and abuse all resources and living beings as means for human ends. The resulting knowledge practices lead to a remodelling of the "environment", which is conceived of as the opposite of the social sphere. Within the framework of this view, according to the critique, the dualistically thinking, industrialised and modern subjects overlook the immense relational complexity of which they are a part (together with all other earthly beings and elements), and jeopardise the collective conditions of survival with their particular projects and one-sided perspectives.

In the following two sections, we first present dialectical-dichotomous concepts about society-nature relations and then relational concepts. But even here it is important to understand that discourses on nature structure nature relations – even in the sciences. As epistemologically anchored knowledge practices, the culturally shaped (modern, instrumental, romantic) constructions of nature (→ chap. 2 on the social construction of nature) lead to specific nature relations from which "we modern people" (Latour 1993) can hardly think our way out of.

2. Dichotomous theories: Different dynamics, co-evolution and interaction in society-nature relations

Two approaches in German environmental sociology represent a critical take on dualistic approaches without completely abandoning the dichotomous perspective: the Frankfurt conceptual framework regarding "societal relations to nature" by authors such as Thomas Jahn, Peter Wehling, Egon Becker, Diana Hummel and others (cf. Becker & Jahn 2006) and the framework for environmental sociological analyses by Karl-Werner Brand (2014). Both approaches reflect the close interconnectedness of nature and society. In the search for solutions to deal with the ecological crisis, however, they and similar approaches maintain the view of nature and society as two independent areas with different internal dynamics, from whose relationships and interactions socio-ecological structures of interaction only emerge in a secondary step. They focus their theoretical spotlights on the investigation of these structures, which, as institutionally fortified framework conditions of society-nature relations, only permit specific socio-ecological regimes (or *socio-metabolic regimes*) despite the variety of possible relations.

2.1. The concept of societal relations to nature

Dialectical perspectives on society-nature relations generally assume a historical intensification of increasing interdependencies between nature and society (→ chap. 1, Figure 2), which they hold responsible for environmental problems. This diagnosis of progressive interaction with risky interrelationships and repercussions is supported by the increasing degree of colonisation, conceived as co-evolutionary, with which human actions (particularly accelerated global economic growth) penetrate, transform and threaten the non-human environment, sometimes intentionally, sometimes unintentionally (Fischer-Kowalski 2011). This

"colonisation" is recorded as an "ecological footprint" (among other things) as part of material flow analyses for different sectors and regions. Material flow analyses and investigations into the "human-ecological systems of metabolism" make a valuable contribution towards raising awareness about the consequences of humans' increasing use and exploitation of ecological resources. However, they are conceptually caught in the dilemma of reducing the complicated dual character of society-nature relations to energy and material flows and largely ignoring the co-production of socio-ecological configurations in appropriation and transformation relations, which are shaped by cultural and socio-economic factors. Rolf Sieferle, for example, described the various mediated society-nature relations as the biophysical metabolism of a growing world population that takes place in three phases that are determined by energy production (Sieferle et al. 2006). Stronger co-evolutionary perspectives focus on the "colonisation" of nature together with the hybrid beings that emerge from it—humans and their artefacts—and on the social organisations that influence natural systems as "socio-metabolic regimes" (Fischer-Kowalski 2011). One criticism of the concept of the progressive colonisation of nature is that nature relations are more multidimensional and shaped by more factors than simply social metabolism. Another criticism is that humans and society were never really outside of ecological (metabolic) relations at any point in time, even if the dualistic opposition behind the problematic interventions hides this fact through cognitive separation and alienation. Nevertheless, the reconstruction of a hardening, progressive penetration of both spheres is useful for environmental sociological analysis.

The perspective of the Frankfurt Institute for Social-Ecological Research (ISOE) is also dichotomously conceived, but is more strongly orientated towards mutually influenced interactions. This perspective deals with the co-evolutionary interweaving of natural and social structures and conditions for action (Becker & Jahn 2006). The genesis of socio-ecological configurations—whether we are talking about their manifestations in modern European cities or in slash-and-burn agriculture in the Brazilian rainforest—is also seen as the historical result of interaction between biophysical and symbolic-discursive structures. In addition, technical, cultural and economic contexts are included in detail. Environmental problems, or problematic socio-ecological constellations, come into view as unintended consequences of an interaction dynamic that has entered a state of crisis. According to this approach, the analytical penetration and processing of environmental problems must start with the practices responsible for their emergence, their institutional framework conditions, the culturally dominant orientations for action, and an understanding of socio-ecological interactions. What is needed, therefore, is a conceptual framework for society-nature relations.

ISOE has been continuously developing this kind of conceptual framework for the last three decades (Jahn & Wehling 1998; Becker & Jahn 2006; Becker et al. 2011). The German Federal Ministry of Education and Research adopted this approach for its socio-ecological research programme in 1999 and promotes wide-ranging, interdisciplinary and transdisciplinary research with the aim of initiating and supporting processes of social transformation that will contribute towards

sustainable development. The aim was and is to overcome the separate consideration of sustainability problems in a) environmental research (which is determined by the natural sciences), and b) in the interpretative approaches of the humanities and social sciences. To this end, problem-orientated knowledge about systems, orientations and decision-making is being developed to help societies deal with their sustainability needs. This explicitly three-dimensional production of knowledge aims to provide an interdisciplinary and transdisciplinary understanding of the intertwined connections and contexts of sustainability problems, to identify and evaluate options for action, and to develop decision-making knowledge for transformative steps (→ chap. 10 on transdisciplinarity). Social justice issues, political frameworks and gender relations are given appropriate consideration and raise awareness about the importance of social power and conflict structures when it comes to the transformation of society-nature relations. In this way, socio-ecological research reacts to the irresolvable connection between ecological problems and social, political and economic developments, and criticises the existing forms of knowledge production in disciplines that are isolated from one another.

Rather, it places the connections and contexts as the central reference point for theory formation and empirical research (Becker & Jahn 2006: 86) at the heart of the theory of society-nature relations or "social ecology". Based on the crisis-ridden relationships between humans, society and nature (as a triangular relationship) and their politicisation, it ties in with critical theory. Thus, the theory of society-nature relations criticises the general production of scientific knowledge as affirmative, problem-ridden and trapped in centuries-old ways of thinking and worldviews, which, due to science's internal boundaries, stands in the way of dealing with socio-ecological problems. However, in order for scientific knowledge to be related to practical social problems, Becker and Jahn argue (with reference to Donna Haraway) that it must be developed into 'situated knowledge' that is relevant to specific contexts and constellations of origin in the border area between the epistemic cultures of the natural and social sciences (Becker & Jahn 2006: 22). Only from the perspective of a new science of social ecology with an integrated focus on the variable forms and configuration possibilities will it be possible to criticise the drawing of boundaries as practices of differentiation, which is carried out by both the social sciences and the natural sciences, and to move beyond the dualisms and dichotomies (Becker & Jahn 2006: 118). The diverse, hybrid composition of the relationships between humans, society and nature then become accessible for analysis as concrete versions of an "ecological configuration" (ibid. 71). Hence, the conceptual framework of society-nature relations exists within the area of interaction between the natural and social spheres, and focuses on evolving, historically and epistemologically shaped relationship patterns (cf. Figure 3). Although the "basic distinction" between nature and society is critically deconstructed as a product of historical practices of differentiation and hierarchies of power, the conceptual framework of society-nature relations retains this as a categorical distinction in order to make logical operations of differentiation and connection conceivable (Becker et al. 2011: 87). To this end, the framework provides conceptual tools to systematically analyse and

compare the time- and culture-specific relationship patterns that human subjects, groups and societies create and regulate in interaction with material and energetic biophysical elements. The tools are used for everything from the analysis of global material and energy flows to the investigation of nature myths and images of society (Becker et al. 2011: 77).

The concept of regulation[5] plays a key role here. It expresses that the conceivable diversity of practically produced, biophysical and symbolic-discursive relationships (as a plurality of society-nature relations) varies empirically only within the narrow limits of established patterns or regimes, just as the institution of marriage limits the diversity of forms of human relationships. Regulatory patterns are the intertwined, dynamic governance relationships between different elements, structures and processes in patterns. They are influential in a wide range of areas, such as food, transport, construction and housing. The term "regulatory patterns" suggests that the elements and structures found in these areas, such as the forms of food supply and demand, typical meals, nutritional knowledge, the types of food companies, technologies and conflicts, as well as the relevant legislation, should not be viewed as isolated phenomena, but rather as an overall configuration. It is emphasised that regulatory patterns are hybrid, i.e., they always have social and material dimensions. Moreover, the regulation of these relationship patterns, which is crucial for the further development and future viability of society, can also be shaped – but not on the basis of just one element, one process or one structure.

These enforced relationship patterns primarily regulate fundamental society-nature relations that serve the indispensable fulfilment of vital basic needs such as food, land use, work and production, housing, reproduction and mobility. They differ globally and in the respective fields of action and are characterised by problematic inequality. The basic nature relations are regulated at all levels of society, so that they can be continued across generations. Due to this general regulation, social groups do not all reinvent their forms of agriculture, mobility or energy supply, but instead shape them according to context-specific regulatory patterns and depending on social norms and power structures (Becker et al. 2011: 81). The theory of society-nature relations does not assume that governments or individual organisations or actors regulate society-nature relations – even if only in one area. Rather, regulation is seen as an overarching phenomenon that only emerges from the context of different strategies. Hummel and Kluge speak of socio-ecological regulations primarily in relation to the secondary problems that arise from technically, politically and economically closely interlinked constellations, which as regulatory problems require ongoing attention (Hummel & Kluge 2006: 251).

The concept of societal relations to nature can be used to examine the historically different forms of relationships that exist both in relation to the external and internal nature of human beings in the various fields of action. This examination takes place at different levels: At the micro level of the fulfilment of individual needs, regulatory patterns are expressed in social norms, culturally specific

5 Regulation is a control theory concept that was developed in political-economic analyses.

practices and social role patterns. At the meso level of social organisations and institutions, the socio-technical supply systems and technostructures (→ chap. 9 on infrastructure systems) influence the manner in which needs are fulfilled, including the unequal distribution and availability of essential goods. At the macro level of (inter)national, but also regional structures, the regulatory patterns of established production, property and gender relations are stabilised as "dispositives" for the fulfilment of needs. With reference to Michel Foucault, the term "dispositive" describes the interconnectedness of the ideas and preliminary decisions embedded in regulatory patterns as an overall framework that determines the possible practices and ways of thinking. The regulatory patterns and dispositives that evolved historically and are institutionally anchored at the macro level influence the scope for regulating society-nature relations at the meso and micro levels and thus limit the possible options. According to the concept of societal relations to nature, approaches for changing regulatory patterns either temporally, spatially or socio-culturally are seen as socio-ecological transformations. They can hardly be intentionally initiated at the lower levels without a corresponding change of the regulatory patterns above. Nor can they be ordered from above as long as socio-ecological practice is regulated by higher-level dispositives. Conceptually, however, unsuccessful regulation is conceivable, which manifests itself in risks, ecological problems and socio-ecological injustice and is deliberately criticised normatively in this approach.

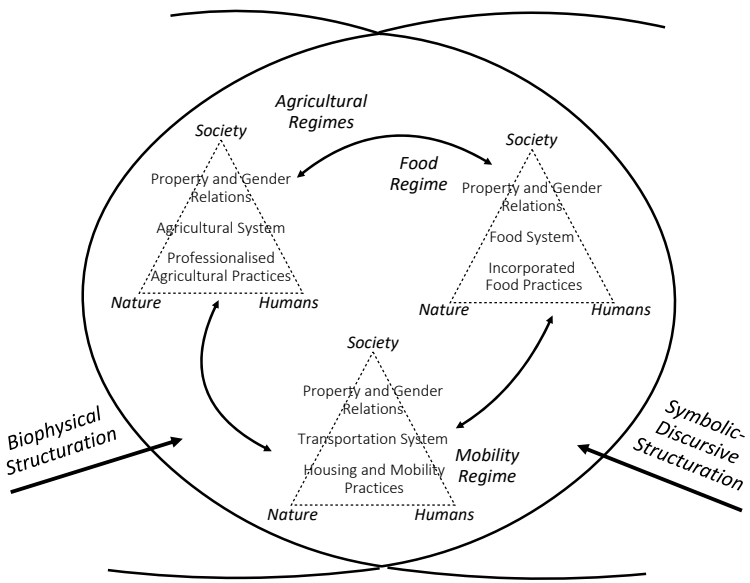

Figure 4: Society-nature relations as socio-ecological regulatory patterns or regimes; source: own illustration

In this figure, we have tried to illustrate how regulatory patterns in different fields of action, in this case food, agriculture and mobility, are a) interconnected, b)

resemble each other, especially at the macro level, c) are co-defined by specific infrastructure systems at the meso level, and d) give rise to typical practices at the micro level. According to the concept of societal relations to nature, these regulatory structures receive special attention as mediators of biophysical and symbolic-discursive effects. In them, the prior dichotomous distinction between nature and the social is illuminated as a more network-like pattern (Becker et al. 2011: 92).

2.2. Nature relations and the socio-ecological regime

Karl-Werner Brand's framework model for environmental sociological analyses is based on the dual character of society-nature relations and also seeks a more comprehensive perspective aimed at analysing the socio-material dynamics of interaction between society and nature (Brand 2014). In relation to the complex interdependencies between society and nature, Brand uses the key category of socio-ecological regimes. Like Becker, Jahn and their co-authors (2006), Brand sees socio-ecological regimes as institutionalised regulatory forms that are culturally anchored in worldviews and ideas about nature, knowledge and non-knowledge structures, dominant technologies and power structures. However, these regimes now do not concern different areas, but rather the epoch- and region-specific overall structure of social relationships with nature (Brand 2014: 151). In this respect, Brand does not assume a plurality of regulatory patterns in different areas, but instead a socially typical, socio-ecological regime. With reference to Hartmut Rosa, he emphasises that contemporary socio-ecological regimes are subject to a dynamic of acceleration in terms of their temporality and a globalised expansion in terms of their physicality and physiogeographic ties (cf. Rosa 2017). This spatial and temporal dynamic of acceleration and expansion transforms all (re-)production processes and the self-image of the subjects. Due to its inherent growth dynamic, which goes beyond the capabilities of institutional control, it leads to an "escalation of side effects" and conflicts structurally with the concepts of sufficiency and sustainability (Beck & Rosa 2014). As a growing spatial incongruence between ecological problems and institutional possibilities for dealing with them (Brand 2014: 102), this dynamic of acceleration makes the deliberate shaping and transformation of society-nature relations more difficult in modern network societies. In addition, socio-ecological regimes are characterised by increasingly interdependent technological (infra)structures, ways of thinking and intrinsic rationalities, which in turn, as socio-technical systems, are part of higher-level economic and societal regimes (→ chap. 9 on infrastructure systems). Their inertia and rigidity also stand in the way of socio-ecological transformation projects.

In his framework model, Brand distinguishes between two levels for the analysis of society-nature relations, namely an *inner* level, which contains the interaction processes between nature and society that are mediated by social metabolism, and an *outer* level, where the resulting feedback processes arise, i.e., the environmental problems as unintended side effects and the social, primarily technical, approaches for solving them (Brand 2014: 155). He suggests analysing the feedback pro-

cesses at the outer level in environmental sociological research in four dimensions, namely in relation to a) their causes, b) the underlying socio-ecological regimes, c) the disaster potential and associated social vulnerability, and d) the social perception and reaction patterns.

2.3. Summary: Society-nature relations and their difficult transformation

All dialectical approaches pay great attention to the history of different relationships with nature and the conflicts associated with them. If, for example, we want to change the patterns and rules of energy supply, we have to ask ourselves which debates provide the context for this to occur? And which political and economic power and conflict configurations will shape these changes? How are regional and economic opportunity structures changing in the course of the energy transition? How can society-nature relations be made more sustainable at the regional, national and international levels and how can the conflicting goals between the social, ecological and economic dimensions be dealt with? Looking at conflicts directs the analytical focus towards the contested perception of environmental problems, towards competing technical approaches for the use of natural resources, and towards controversial interpretations of climate change or technology risks. Ecological problems, technology opportunities, economic and political goals within and outside science are examined in relation to contested findings about their relevance. The study of natural, technological and environmental conflicts also takes into account the various social and economic models on which the conflicts are based and discusses their significance for socio-ecological problems.

Dialectical perspectives therefore look at the biophysical consequences of controversial forms of use and shed light on their multidimensional backgrounds, for example by comparing different forms of energy production. On this basis, they discuss the potential for change in spatial, temporal or factual comparisons. As a result, they move back and forth between the natural and social poles of society-nature relations. Dialectical approaches look at socio-ecological regimes and their resulting repercussions and interactions, and look for ways to identify the undesirable consequences of enforced regimes of nature relations in the supply systems in order to support transformations towards more sustainable and fairer nature relations, which must start at all the necessary levels. Such approaches also take into consideration the inertia of the regulatory patterns and regimes that are interlinked in a variety of ways. The advantage of these co-evolutionary approaches is their sensitivity to the dynamics of the crisis-ridden relationships between humans, society and nature and to the multidimensional configurations of socio-ecological problems. The disadvantage seems to us to be their strong focus on functional relationships with nature and, depending on the perspective, their tendency to conceptualise one of the two nature-society spheres as monolithic and passive, and the other as powerful and multifaceted. In our view, Brand's conceptualisation of epochal and cross-sectoral social-ecological regimes (2014: 151) tends to simplify the complexity and conflict potential of nature relations in a dichotomous manner. In contrast, the concept of societal relations to nature takes greater account of the interconnectedness of hybrid relationships (Hummel

& Kluge 2006: 248) and, in the search for solutions, illuminates their dynamic and crisis-ridden transformation beyond concepts of control (ibid. 238, 256).

Dichotomisation always harbours the danger of viewing nature and society as mutually exclusive and homogeneous units and thus underestimating the complexity of socio-ecological problems and their socio-political, technical, economic and material interrelationships, including the mutability of the human and non-human beings operating within them. As a result, the analysis reverts to the base level, which we criticised at the beginning, of viewing socio-ecological transformations as an external influence that society and its socio-technical innovations have on nature or, conversely, of reifying the natural limits and conditions on social possibilities for action. Consequently, the contradictions, conflicts and dynamics in various nature relations and their registration in and transformation by socio-technical arrangements are only schematically considered. Instead of interpreting the relationships between nature and society as a dichotomously structured interrelationship, the relational approaches considered in the next section begin by viewing these configurations as a complex variety of assemblages and interwoven "enabling relationships".

3. Relational theories: Fluid relations, contested assemblages, and intra-action in nature relations

The theories and concepts of society-nature relations discussed in the first section do not consider concrete and in some circumstances specific relationships between human beings, non-human living beings and biophysical factors, but instead analyse these relationships in an overarching, overall context. They examine society-nature relations from the macro perspective of social theories and, in particular, analyse the social background of environmental crises, species extinction, and climate change. As we have seen, they explain relationships with nature by looking at underlying constructions of nature, overarching dispositives and regulatory patterns. Essentially, the phenomena analysed are thus attributed to natural or social factors and these are consequently presupposed.

Relational approaches reject this strategy and its reference to higher-level explanatory variables. Instead, they insist on thinking in terms of temporary partial connections and changing assemblages of human-nature-thing relationships at the micro level, and view this as what creates the macro level in the first place (Callon & Latour 1981). Subsequently, relational approaches regard the social and the natural not as the origin but as result of previous assembling activities (in French: *assembler*). Gilles Deleuze and Félix Guattari (1987) took the term assemblage from art, where it generally referred to combinations (e.g., collages), and used it with various definitions to describe co-functioning, volatile and heterogeneous combinations of practices, objects, and spaces. Bruno Latour (2007) and Manuel DeLanda (2016) elaborated on their thinking and have contributed towards an assemblage theory of contingent but consequential interconnectedness. As the following quote illustrates, the initial focus is on heterogeneous alliances and their active but fleeting formation:

> "What is an assemblage? It is a multiplicity which is made up of many heterogeneous terms and which establishes liaisons, relations between them, across ages, sexes and reigns – different natures. Thus, the assemblage's only unity is that of a co-functioning: it is a symbiosis, a 'sympathy'. It is never filiations which are important, but alliances, alloys; these are not successions, lines of descent, but contagions, epidemics, the wind" (Deleuze & Parnet 1969: 69, cited in DeLanda 2006: 1).

Relational approaches take an unbiased look at the emergence of contexts. They are interested in their possible diversity and interactive development into assemblages, associations and networks. In this networking perspective, identities and social roles only emerge through relationships with one another and are transformed through processes of appropriation and exchange with one another. They are thus considered neither predetermined nor pre-structured by intrinsic macro characteristics. Assemblages are formed from relationships between organic actors (human and non-human organisms) and technical devices (from pacemakers to nuclear power plants) and biophysical factors (climate, water, temperature, soil conditions, etc.). The concept thus explicitly overcomes the "Great Divide" that modern science has drawn between nature and society (Latour 1993), and with it the obliviousness of many sociological approaches to nature, facts and technology. Instead, relational thinking in terms of interrelationships and networks involves continuous exchange relationships. Figure 5 attempts to visualise this, even though the dynamics, interactions and adaptability are difficult to depict. The relationships in assemblages are diverse and reciprocal. They can be, among other things, parasitic, symbiotic, reinforcing or weakening, such as those between bees and beekeepers, bees and flowers, bees and sugar, or bees and pesticides. From the perspective of relational theories, the hybrid assemblages of living things and scientific/technical, organic and inorganic components emerge from reciprocal interactions that are both spatially and temporally situated as "ongoing stories" (Haraway 2016: 40). They change co-evolutionarily in the course of shared and interwoven stories of "becoming-with" (Haraway 2016: 12).

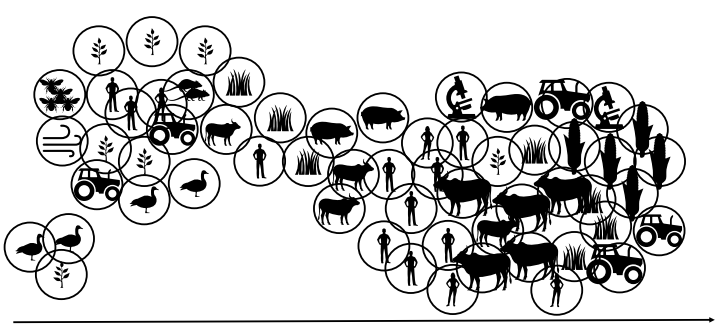

Figure 5: Relational co-evolution of variable elements in hybrid contexts; source: own illustration

This means that we cannot assume stable actors, stable environments, secure forms of appropriation, influencing factors or indeed social or ecological systems that determine framework conditions. Instead, in this networked togetherness, common conditions are only created through relational change. Some of the authors are thus reacting to concepts of biology that do not assume independent organisms and environments, but rather view the entire biosphere as a living being that is constantly changing, as suggested in particular by the "Gaia hypothesis" proposed by James Lovelock and Lynn Margulis (Lovelock & Sagan 1974). It emphasises the mutual interconnections, feedback and dependencies in complex interactions (cooperation and symbiogenesis).

As we explain below, non-human "actants" or "agents" are also regarded as actors capable of acting or having an impact. They are no longer regarded as exclusively passive, completely determined objects, but as interacting entities in social relationships. Their contributions to human society are discussed in four ways (Sayes 2014: 135): as the basis for the possibility of human societies, as mediators in social relations, as delegates of moral-political intentions, and as components involved in the assemblage of networks of agents with variable ontologies[6], times and spaces.

These conceptual shifts towards a methodological statement of the necessary consideration of hybrid assemblages and non-human *agency* mean that relational approaches negate deterministic understandings of human-nature-society relationships, essentialising[7] dualisms (human-animal, society-nature) and one-sided objectifications and hierarchisations, such as the narrative of humans' mastery over nature or their technical superiority. Although relational approaches recognise that anthropogenic processes have had planetary effects—the Anthropocene thesis—they also point to interactions with other species and elements involved that are also influential, such as viruses, bacteria, technologies, and climatic conditions. According to the relational critique of dichotomous approaches, the manifold interactions between these different agents[8] and their consequences would remain hidden in a priori distinctions and linear narratives, e.g., in the humanistic notion that humans occupy a special position in the world. In the following, we will present examples of the three best-known approaches that are particularly influential in the sociological discussion of society-nature relations.

3.1. Stories, figurations and the diversity of kinships in Donna Haraway's work

Donna Haraway is one of the most influential pioneers of relational concepts for analysing human-society-nature relationships. She is a biologist, philosopher and historian of science. In her dissertation, she considered the role of metaphors in the history of developmental biology (Haraway 1976) on the basis of Thomas

6 Ontology is the philosophical study of "being", which deals with what constitutes being or existence and what meaning it has.

7 The term essentialism describes a philosophical view according to which subjects or objects have an unambiguous, clearly definable, unchangeable essence (Latin *essentia* = essence).

8 The term "agents" is used here to summarise the various terms that will be introduced below (actors, actants, agents, companions).

Kuhn's work (1997 [1962]), who interpreted epistemological progress as contested shifts in schools of thought and paradigms. She focused on the power of thought patterns to structure knowledge and used the writings and lifeworld environments of three influential scientists to trace how their controversies about mechanistic, pattern- or organisation/system-related concepts, which were influenced by developments in neighbouring disciplines, led to a paradigm shift in the analysis of organic development processes. The major dualities that characterise the discipline of biology—structure-function, epigenesis-preformation, form-process—had been reformulated in the course of a disciplinary crisis in these processes of knowledge production (Haraway 1976: 17). According to Haraway, it was visual metaphors and exemplary objects of investigation that essentially structured the thinking of the scientists and their communities (ibid. 189) and linked it to overarching worldviews: "The barrier separating organicists and reductionists will not be breached by empirical study, because in the end people believe different things about the structure of the world" (ibid. 198). – even though at the same time they believe "that science can reveal nature" (ibid. 199). In her first book, she points out that thinking about natural phenomena is co-determined by symbolic and socio-political contexts, yet such thinking nevertheless refers to a reality that is conceptualised as ahistorical and referred to as "objective", while co-constituting material-semiotic worlds. In relational approaches, the adjective "material-semiotic" dissolves the dialectically conceived dichotomy of biophysical and symbolic-discursive structures. Authors use it to mark the fact that their objects of investigation, whether they are people, regulatory patterns, environmental problems or viruses, always owe their existence simultaneously to both material and discursive processes of production.

Inspired by her involvement in the women's rights and peace movements, Haraway developed her epistemological reflections on the material-semiotic production of knowledge into a feminist critique of science and society. Her discourse analyses of biological studies of the immune system and in primatology, alongside her writings on the theory of science, including "Situated Knowledges" (Haraway 1988), led to the much-cited "Manifesto for Cyborgs", which was first published in 1985 (Haraway 1991). In this manifesto, she calls for recognition that the distinctions between humans and animals, men and women, but also between nature and technology are made differently at different times and under different conditions, because "nature"—the supposed reference point—shifts with the material-semiotic conditions in which it is constructed, just like its counterpart, the concept of "culture". In order to make alternative and hybrid material-semiotic cultures of nature conceivable, Haraway allows the marginalised voices of *women of colour* and techno-utopian science fiction to have their say.

Using ironic terms such as "cyborg"—a hybrid of human, machine, science, fiction, imagination and experience—she attempts to undermine dualistic divisions and ways of thinking. In order to liberate the concepts of nature and culture from disastrous definitions and to be able to reconceptualise them along the lines of lived relationships, she meets the nature/social border wars with deliberately epistemological standpoints: positions from which responsibility for the conse-

quences of the scientific/technical constitution of reality can be taken and which are "committed to changing the world" (Haraway 1991: 159). Haraway thus also opposes ecofeminist and social constructivist approaches. She criticises the fact that these still subscribe to ideas about a supposedly stable authenticity ("female experience") and that they exaggerate the power of social discourses. As such, she argues, they can neither grasp the opportunities for self-determination found in the infinite repertoire of human-technology-nature relations nor the implications of the emerging field of *technoscience*[9]. Haraway's cyberfeminism project, on the other hand, is based on an epistemological infiltration of the dominantly organised dualisms and their justification of oppressive and exploitative relations. Through discursive, cultural, but also scientific/technical possibilities of situated, temporary and partial hybridisation, interconnectedness and, as we will see, the formation of sisterly bonds, she wants to open up alternative figurations beyond subjugation stories.

In her work, Haraway thus fundamentally rejects the universal epistemological perspective with its typical dualisms and, in particular, the claim of scientific subjects as "*modest witnesses*" who pretend to report objective truth about scientific objects. She is critical of this claim to knowledge that is free of cultural or biologically induced bias as it is only granted to privileged Western men, while women, people marked as belonging to the Global South or workers are always coded and objectified as the Other, just like non-human scientific objects. Instead, she argues in favour of consciously situated perspectives[10] within the sciences and beyond, which she also adopts in her own representations, for example when it comes to dogs, pigeons or bacteria, which she refers to together with humans as "critters" or "companions" at the feeding trough (Haraway 2016)[11].

In addition to feminist perspectives, the ongoing discussion of Michel Foucault's concept of biopolitics plays a central role in Donna Haraway's work. In his 1970 lecture "The Order of Discourse", Foucault (1971) had placed power aspects at the centre of the study of knowledge production. His discourse analyses promote the epistemological insight that orders of discourse curtail, channel and control the production of knowledge and meaning through the specific mechanisms of procedures of exclusion, classification and regulation. Discourses, he argues, constitute not only subjects and objects, but also the processes of their "production" and the dissemination of the corresponding knowledge. Against this background, Haraway defines situated knowledge as a locally produced, multilingual, interwoven and subversive knowledge that makes the traces of its creation visible (Haraway 1988). In contrast, she criticises the claim to absoluteness of supposedly objective, neutral scientific approaches and their often implicitly patriarchal,

9 The term *technoscience* was first used by Jaques Derrida, then taken up by Bruno Latour, and since then it has been used in *Science and Technology Studies* as a cipher for the intensified combination of technological, scientific, and economic practices of industrial capitalist and military production in the twentieth century, for example in biotechnology or, most recently, the development of artificial intelligence.

10 Situatedness means no universal and neutral knowledge is produced, but that knowledge is always culturally and temporally "located", i.e. situated, as we explain below.

11 To better understand Donna Haraway's work, we recommend reading "Staying with the Trouble. Making Kin in the Chthulucene" (2016).

anthropocentric and racist character, and counters them with avowedly activist and oppositional standpoints.

Even "nature" is no longer to be merely the "raw material of culture", "appropriated, preserved, enslaved, exalted, or otherwise made flexible for disposal by culture in the logic of capitalist colonialism". Instead, nature is to be "pictured as an actor and agent" (Haraway 1988: 592). Haraway does not assume a pre-existing world with stable beings which are there prior to any interaction and which can be discovered. Instead, with reference to Latour, she clearly stated in an interview that nothing exists before this relationality (Penley et al. 1990). Even a cell does not simply wait to be appropriately described, but is contingently embedded in specific relationships between instrumental, social, material and literary technologies and is nevertheless real. As a consequence, Haraway portrays the "cultures of nature" that are encountered as effects of historically malleable power relations and at the same time concentrates on the stubborn and subversive practices of overcoming one-sided processes of attribution. She sees the recognition of the *agency* or *agencies* of non-anthropomorphic beings as "material-semiotic actors" as the only way to liberate the entities assigned to the natural sphere from objectification and to transform them from determinate means into ends in and of themselves. Whether it's about gender or the agency of pigeons, she always explores the concrete relationships, the embodied and variable constitution of her ephemeral objects, and their situated practices of demarcation, using the ethnographic methods typical of Science and Technology Studies.

Her book "Staying with the Trouble" (2016) focuses on unstable relationships, associations and kinships – cross-species and multiform, between humans and machines, humans and dogs, corals and pigeons. In the face of overpopulation, species extinction, and climate change, Haraway advocates for people to "Make Kin, Not Babies" (2016: 103). She urges her readership to see themselves as "earthlings" (ibid. 103) and become kin to other mortal species, and to abandon the destructive understandings of the self that are informed by purpose-driven individualism and anthropocentrism, along with globalising cosmopolitanism and the epistemology of human exemptionalism. Her motto is "becoming-with instead of becoming" (ibid. 71): To this end, she tells hybrid "ongoing stories" (ibid. 40) instead of essentialisms and universalisms, thus opening our eyes to previous and possible future entanglements. At the heart of her explorations is the search for relationships that allow for mutual empowerment, for making a difference for each other and with each other, to increase the capabilities of all players, not to diminish them. Haraway assumes that subjects and objects, living beings, technologies and "environmental factors" emerge in a network of relations in which bodies, ideas and capacities for action are only produced and transformed in reciprocal relationships. This represents a radical understanding of the situated co-evolutions of "material-semiotic worlds" that are capable of being shaped and in which permanent answers for living together must be found. These lived responses are necessarily partial, selective and not always compassionate, but also prone to conflict and violence, because nothing can connect with everything and support everything (Haraway 2016). That which is material becomes manifold

and fluid in them, so that Haraway is considered a pioneer of New Materialism, in which the one-sided view of discourses, bodies and constructions is dissolved.

We should "stay with the trouble" in the face of the reductionist determinations of naïve naturalism and radical culturalism (→ chap. 1), but also in the face of the idols of progress and capitalism, which Haraway, with reference to the concept of the Capitalocene, holds responsible for the problems of the present. For her anti-categorical accounts, she chooses a restless style of writing that is associative rather than analytical in order to avoid determinism and identity politics. She wants to explore cross-species relationships in a caring and considerate way, break through categories, investigate complex figurations and tell open stories about hybrid figures from different perspectives, especially those that make it possible "to cut the bonds of the Anthropocene and the Capitalocene" (Haraway 2016: 5). She views storytelling itself as a "knowledge-political" *worlding practice*. For this, she repeatedly emphasises, it matters what concepts are used, "what stories make worlds, what worlds make stories". (ibid. 12). The key question in the Anthropocene is whether and how cross-species, responsible relationships can be narrated, composed, disassembled, and generated in the heterogeneous and interwoven fabric of thought and life. Haraway suggests it is primarily the sciences that are responsible for answering this question, alongside art and science fiction. They should tell complex, engaging stories by depicting relationships with an eye for the diversity of relations and interactions, and by exploring risk-sensitive "worlding practices" (ibid. 86). As one of many examples of this, Haraway cites Bruno Latour's Gaïa stories that describe the search for critical zones in which shared existence is possible. We will take a look at these stories below.

3.2. Actor networks, propositions and associations in Bruno Latour's work

Like Haraway, Bruno Latour's examination of society-nature relations began with science studies, i.e., the investigation of how knowledge about nature and natural elements comes about. Latour first used ethnographic methods in laboratories and libraries to investigate the practices by which knowledge about living beings and biophysical entities is produced and subsequently distributed in the sciences within a framework of diverse translation processes. These studies illustrate how natural phenomena are simultaneously constituted and integrated into overarching networks related to their social utilisation and application. This makes it clear how little these practices correspond to the modern claim that an independent, external nature is "discovered" by neutral scientific investigation. In a study published jointly with Steve Woolgar in 1979, "Laboratory Life. The Construction of Scientific Facts" (Latour & Woolgar 2008 [1979]), the team of authors turned the ethnographic gaze from foreign, colonised peoples to the laboratory as a culturally exotic world and reported on it in the style of the great explorers' accounts. The study records in detail how scientific findings emerge from individual laboratory findings, measurement protocols, statistical series, lectures and note-taking techniques, always embedded in the available laboratory equipment, research routines, personal interests and elaborate processes of coordination, in order to finally end up as decontextualised "facts" in publications.

These and other ethnographic studies in the laboratories of renowned scientists contributed to the emergence of *Laboratory Studies*, which follow the production of knowledge and the recording of the world in everyday scientific and technical laboratory practices. Latour and Woolgar's analytical work centres on linguistic metaphors, discourses and symbols, social interests and needs for distinction, but also includes the laboratory instruments and the neuroendocrinological objects of investigation themselves as relevant elements. They are worthy of attention as participating "actants" because their involvement in social laboratory practices is necessary for the scientific attribution of facticity. Objects are thereby accorded a certain *agency*: Hormones, apparatuses, specialist histories and researchers jointly enable "inscriptions" – inscriptions that produce reality as networks of actors, but which later disappear behind facts in the scientists' reports[12] or are made invisible by the reifying black boxing of scientific representation. Laboratory Studies aims to unpack this black-boxing of scientifically produced facts, to reveal the underlying socio-technical arrangements behind the fabrication and distribution of agency, and to make the construction processes and consequences of *matters of fact* into public matters, into *"matters of concern"* (Latour 2008).

On this basis, Latour subsequently elaborated the actor-network theory together with, in particular, Madeleine Akrich, Michel Callon and John Law. Initially, this was done as a methodology guiding research, later, and especially since the publication of the book "We Have Never Been Modern" (Latour 1993), as a social theory critical of the present. Actor-network theory (ANT for short) has been taken up by many disciplines around the world and provides significant impetus and one of the most widely discussed theoretical points of reference for environmental sociology and the sociology of technology. Its development is directly linked to science studies and extends it in three directions, which we will explain below, namely:

1. the extension of the attribution of agency beyond the laboratory to all socio-technical arrangements and their natural, technical and material elements,
2. the fundamental consideration of classifications and identities as the temporary result of translation and stabilisation processes in actor networks (rather than as ex ante starting points), which, however, are ignored due to a self-deception that is constitutive of modernity, and
3. the necessary realisation and careful negotiation of these networking and composition processes from a democracy theory perspective within the framework of political ecology.

Firstly, Latour introduced the almost anecdotal extension of the consideration of agency not only in relation to human, but also to non-human and technical actants, as a counterpoint to the uncritical adoption and reproduction of essentialist assumptions about people, culture, nature, and technology. Just as the emergence of scientific knowledge has been examined and portrayed, sociological knowledge production should also be critically reconstructed. How does "the social" come about? Who is acting, for example: the EU, the current EU Commis-

12 Latour speaks of *factish* – a cross between faith and facts (Latour 1999).

sion President, old European preferences or the emissions directive for new cars? They all "prescribe"; they are "different ways to make actors do things" (Latour 2005: 55). In Latour's relational ANT, all the aforementioned actors and actants are agents that differ only in the degree of their respective figuration, that is, whether they are already determined as collective or individual actors. In this sense, ANT transfers concepts from sign theory—as a conceptually less captious "infra-language" (ibid.)—to epistemology and ontology in order to protect itself from an essentialist reproduction of categorical attributions. As a consequence, "society" is not already there, but must be understood as the result of hybrid, mobile associations in which a multiplicity of entities[13] relate to each other in a network-like manner and reproduce themselves in an entangled way. Not only in the laboratory, but in general, all relevant elements should be included in the understanding of socio-technical assemblages, including lactic acid bacteria, key racks, door openers, speed humps, reactors and soil crumbs, because they stabilise social associations, make reciprocal determinations and thus open up or close off opportunities for mobilisation and networking. Bruno Latour was interested in the social, i.e., interactive, complementary and controversial constitution of "compositions" – the actor networks. He advocated for a "new sociology" (2007) to adequately grasp the associated processes of forming and limiting agency, assertiveness, power and control, in which a wide variety of entities are included, modified, and reprogrammed. The new sociology should not continue to exclude the natural, material and technical from the outset, but should consider it equally ("symmetrically") in the development of theory due to its considerable importance for the stabilisation and destabilisation of modern societies.

The study of the contested processes of establishing and dismantling networks and assemblages is also at the centre of many case studies in Science and Technology Studies, in which the methods of ANT are used to trace the formation of hybrid arrangements in various fields of action. Central to these methods, in addition to the symmetrical approach without prior distinctions, is the reconstruction of processes of mediation and "translation" (Callon 1984): This traces in detail how agency, materiality, knowledge, and meaning emerge from interrelated operations of mediation and networking, as well as efforts to stabilise them, how they change, and how they can also fall apart again (Latour 1996). Social action is thereby always conceived as inter-action, as action that is shared with and distributed to multiple entities. From this perspective, innovation processes in particular are a major source of the continuously growing number of hybrid entities derived from what is called nature and technology as well as organisation and technologisation (Akrich et al. 2002). For environmental sociology, this relational approach changes the picture significantly: The earlier large-scale concepts of nature and society with their dichotomously conceived characteristics are replaced in ANT by temporary associations between heterogeneous and hybrid actants and elements that transform each other reciprocally. In his early study "The

13 In case studies and thought experiments, humans, animals, plants, bacteria, technologies and materialities, but also socio-technical configurations such as ships, transport facilities and economic goods are observed as co-acting entities (cf. Sayes 2014: 136).

pasteurization of France" (Latour 1988), Latour devoted his attention to the biologist and French national hero Louis Pasteur, who brought together a variety of competing forces, including microbes, farmers, pasture fences, industrialists, and politicians. Thus, he not only succeeded in explicating microbes, but by developing scientific knowledge about them, he was also able to redefine French stables and hygiene practices: in short, all of society. Compared to Haraway, who tends to presuppose patriarchal and capitalist interests, Latour paid more attention to the interests and programs of the actants involved, the negotiations that lead to their connections, and the attempts to harden the inherently unstable, mobile network and render it unavailable to further attempts at incorporation, than he did to "knowledge-political" or, as he wrote, "cosmopolitan" endeavours.

Secondly, processes of mediation and translation, as well as the disregard for those processes that is typical for modernity, play a crucial role in ANT. The concept of translation processes is invoked to explain that innovation and transformation processes not only lead to "something new entering the world" (the simple but inaccurate implementation notion), but that the things that already exist also have to be transferred or shifted into new arrangements with new kinds of agency, roles, and identities. In Latour's words, it refers to the "creation of a link, that did not exist before" (Latour 1994: 32) between two arrangements through which all the elements and agents involved are modified and assume a new position in the emerging network. It is true that in innovation processes, on the one hand, new kinds of networks and connections are created (e.g., for electromobility, high-performance cows, biotechnical cultivation methods and markets, buildings, or energy supplies) that undermine and redefine previous distinctions (Latour 1994; Callon 1984). And these new formations leave traces as "the result of ongoing practices through which actors, in the course of their interaction, elaborate ad hoc rules to coordinate activities" (ibid. 50). This makes it possible to study the process by which they are assembled and fabricated by looking at the controversies surrounding their arrangement. For example, which networking actors succeed in bringing together batteries, vehicle chassis, charging infrastructure, tax incentives, car manufacturers, and drivers in such a way that they eventually displace the internal combustion engine? Which actors and elements will be left behind, who will have to change their goals, their characteristics, and their relationships in the context of which controversies? These questions can be investigated with the tools of ANT and shed light on the underlying "linking" or "mixing" that is used to recruit participants and to network different roles, interests, capabilities and resistances in such a way that all participants change their positions and together form reality as a new socio-technical arrangement.

On the other hand, and herein lies the critique of ANT in terms of Science (with capital S) and social theory, both the scientific disciplines and society's self-image and risk management negate precisely these processes of involvement, engagement, mobilization, and representation (Latour 1993; Callon 1984). According to the central thesis, nature and society, humans and technology, global and local, macro regulatory patterns and micro-actions are again separated and differentiated (despite their obvious intermingling) due to a kind of consti-

tutionally anchored, "knowledge-political" purification process. This makes the de facto composition invisible, so that no collective responsibility is taken for its consequences. The growth of risky hybrids that is permanently driven by science and technology—the products of biotechnology or cyber-physical systems controlled by artificial intelligence come to mind—therefore escapes institutional control, for instance through legal and democratic institutions. This growth and its potentiation through global value chains, whose increasing risks are ever more opaque, takes on the form of an escalating revolution of the side effect (Beck & Rosa 2022: 153) that threatens to present modern societies with problems that are almost impossible to solve. Yet this growth is quasi "constitutionally" out of society's sphere of perception. For these reasons, Latour avoided the term "climate change", which linguistically suggests that it is about the change of the (external) climate, and criticizes both climate research conducted only in terms of natural science and social science approaches that are limited to the study of societal climate consequences and discourses. Instead, he favoured talk of "global warming", which better sensitises us to the underlying processes of the shared, multifaceted, and risky transformation taking place in the human-technical-ecological collective: "We may then be able, finally, to understand these nonhumans, which are, I have been claiming since the beginning, full-fledged actors in our collective; we may understand at last why we do not live in a society gazing out at a natural world or in a natural world that includes society as one of its components. Now that nonhumans are no longer confused with objects, it may be possible to imagine the collective in which humans are entangled with them." (Latour 1999: 174f.).

Latour (Latour 2005: 185ff.) uses the terms "proposition" and "articulation" (Latour 2005: 199) to open up an alternative view of ecological, technical, and material elements in actor networks. While the "modernist constitution" externalises them as neutral tools or a force majeure, ANT internalises them as "mediators" from which impulses emanate and which need to be adequately represented. The non-human is thereby not seen as a neutral means or mediator between human agents (such as microbes or cows between farmers and consumers), but as players who can intervene in these relations and in the definition of these relations, not without changing itself (Latour 2005: 37)[14]. But if complex social associations have to be permanently fought for and performatively maintained, as per the political argument of ANT, then a framework must be found for the responsible organisation of these processes of hybrid networking, such as a "parliament of things" (Latour 2004). The aim of this parliament would be to determine together and from a variety of perspectives, which links the various members of existing collectives want to enter into, which risks and costs they are willing to accept and how they can live together in a shared world. These questions and their equally epistemological, sociological and political discussions have formed a kind of (cosmo)political ecology and have been a focus of publications over the last two decades.

14 Beat Sterchi's novel about a cow called Blösch makes this clear.

Thirdly, Bruno Latour turned his attention to the problems caused by growing chains of hybrids and their side-effects, i.e., the major challenges that threaten the present and the future, such as the hole in the ozone layer, species extinction, overheating of the planet and pandemics. So if living beings, society, technologies, artefacts and science do not act independently of each other and cannot be conceived of separately, but instead—as described by ANT—form a hybrid "collective", then, according to Latour's democratic-theoretical conclusion, the question arises as to how the consequences of the hidden translation practices such as species extinction and global warming can be internalised: How can institutional procedures be found for the development of less risky forms of coexistence? Since the complex problems can no longer be attributed to technical constraints or the laws of nature, given that ANT has revealed the tangible interests, political claims and moral prescriptions involved in their multiplication and expansion, ANT consequently calls for a framework of prudent diplomatic mediation in order to tame the risks democratically through the careful articulation and negotiation of interests. The carefree proliferation of unstable hybrid beings is to be channelled into a public "cosmopolitics" (Latour & Weibel 2005) in order to enable the joint production of good (we would say "sustainable") arrangements in the thin, "critical zones" of the planet. Hybrid production should consequently be slowed down, better articulated, controlled and democratised (Latour 2004). In his book "Down to Earth" (Latour 2018), the original French title[15] of which would translate as "Where to land?", Latour called for the abandonment of the globalising, placeless view of the Earth in favour of the renewed acknowledgement of our "earthboundness". Since people neither look at nature from the outside nor are they part of a predefined nature, yet are nevertheless exposed to the interactions of everything earthly, it is necessary to institutionally and politically redefine the coordinates of the political. Beyond the modernist orientation points of global-local and, related to this, progressive-conservative, Latour claimed that the careful composition of a liveable Earth is at stake, recognising the fact that the geopolitically available space for this is limited. Europe appears to him as a suitable starting point for this: "Theres nothing like an Old Continent for taking up on a new basis what is common, while observing, with anguish, that the universal condition today entails living in the ruins of modernization, groping for a dwelling place." (Latour 2018: 106).

Latour stated, however, that in the "new climate regime" (Latour 2017: 3) so far the opposite has taken place. The incessant deepening of ecological risk situations is justified by the overpowering constraints of capitalism, competition and nationalism (not only by Trump, etc.) and is presented as insurmountable, so that in these ruins of modernisation it is no longer nature that is externalised as pre-existing and uncontrollable, but the self-endangering social order. In his last book, "Où-suis-je? Leçons du confinement à l'usage des terrestres" (2021; in English: After Lockdown: A Metamorphosis?), he took up the experience of lockdowns and restrictions to people's freedom of movement caused by the Covid pandemic as a dress rehearsal of future geosocial localisations. Earth's inhabitants should

15 Où atterrir? Comment s'orienter en Politique (2017).

use the painful experiences of human connectedness with everything earthly for the exploration of those critical zones in which they will live in the future due to the co-produced pandemic-prone and heated world. The planetary is political, one could summarise, and therefore the search for freedom and emancipation must be resumed in a way that is more compatible with the rather strange forms of complete internalisation between new coordinates, perhaps those of extractivism versus commoning.

3.3. Agential realism and intra-action in Karen Barad's work

More recent developments in relational approaches include the theories of "new materialisms" (Coole & Frost 2010). The most important proponent of these theories is the physicist Karen Barad. Her work follows in the footsteps of Michel Foucault, Judith Butler, Donna Haraway, Bruno Latour and the quantum physicist Niels Bohr. They have all countered the universal view of truth, knowledge, structure and matter in a poststructuralist way by highlighting its historicity, situational production and "knowledge-political" changeability. Barad is likewise concerned with the relationships between humans and the reconfigured world that they themselves have changed. She also focuses on overcoming dualistic assumptions about agency and cause-and-effect relationships, and on the relationship between material phenomena and the social practices of their representation (Barad 2007: 34). With her programmatic consideration of matter and materialisations, Barad radicalises relational approaches from the perspective of a feminist science theorist. She, too, decisively distances herself from anthropocentric humanist epistemologies; she does not conceive of human subjects as external or independent and equipped with special capabilities for action and agency that mean other (biophysical) phenomena are dependent on their will. Based on her insights into the constitution of scientific knowledge, she instead calls for a fundamental rethinking of our understanding of scientific rationality, laboratory practices, their results and their ethics of responsibility, because the relationships between humans and other agents, according to the term used here, are epistemologically and ontologically uncertain and unstable, but nevertheless objective.

Barad thus also assumes a situated knowledge that is dependent on measuring devices ("apparatuses") and thus inevitably a partial knowledge. She looks at the participation of "agentive" (i.e., effective but fluid) matter that has changing properties in the cognitive process (Barad 2007: 137)[16]. She conceives of "phenomena" such as the observer and the observed (speaker positions, bodies, atoms) as interdependent. According to Barad, bodies and matter are not passively and determinately involved in the production of knowledge, but instead

16 In this respect, Barad builds her conceptual reflections about the epistemological and ontological multiplicity of matter on her interpretation of Werner Heisenberg's uncertainty principle and Niels Bohr's complementarity principle, which are explanatory approaches that were developed in physics to deal with the mutually complementary and mutually exclusive observations of wave-particle duality (Barad 2003). Trevor Pinch (2011: 434), in turn, criticises Barad for attributing an authoritative character to this production of knowledge in physics, thereby overshooting the goal of including forgotten matter because she herself now forgets social constructivist analyses of the social embeddedness of knowledge.

interact and intra-act in an epistemologically controversial, ontologically unstable and politically resistant way – not least because they are first formed as material-discursive phenomena by boundary-drawing apparatuses. At the centre of her theory of agential realism, which is conceptually an oxymoron, is therefore the concept of "intra-action". Barad uses this concept to focus on the relationships *within* the subjects and objects of phenomena or materialities rather than the relationships between them, which in principle only come into the world as the result of relationships: "Neither discursive practices nor material phenomena are ontologically or epistemologically prior" (Barad 2003: 822). She thus takes up Foucault's thesis of the epistemological production of subjectivity and power (and the power to define things), but without limiting this to the realm of the social or subordinating the realm of the non-human, material to these practices. Rather, she argues that "agential realism takes account of the fact that the forces at work in the materialization of bodies are not only social, and the bodies produced are not all human" (Barad 2007: 33f.). For her agential realist conception of power, she therefore reworks the traditional understanding of causality into a concept of "intra-activity", which "signifies the mutual constitution of entangled agencies" (ibid.: 33). Again, agency is the result of an interplay, in this case of the complex activation of different agentive entities that cannot be recognised and distinguished in advance, because they are only (re)constituted in the processes of intra-action. In contrast to Haraway and Latour, however, the prior distinctions implode not only in relationships and new hybrid beings, but also in the active or acting subject or object.

Subsequently, Barad also consciously takes an epistemological position and conceptualises matter[17] as temporary, productive, relational, and complex entities that produce transformations and are only ever selectively captured by apparatuses. She understands the necessarily situated knowledge not as a scientific failure, but as constitutive for the investigated elements, which would not exist without their partial illumination in laboratory facilities, and the same applies to the observers themselves. For they, too, do not exist outside the world and simply observe it in the laboratory, but instead create themselves and their worlds intra-actively, co-constituting them. For the intertwined productions of ontology and epistemology, Barad, like Haraway and Latour, calls for a conscious, post-humanist and responsible attribution of responsibility, and for the entanglements of ethics, knowledge and being to be taken seriously (Barad 2007). However, it remains unclear from which standpoint responsibility can be assumed for more than situational micro-relationships.

We will leave it at that with our brief description of agential realism. It is important for us to emphasise that this radically relational perspective does not stop at the external boundaries of the elements and actors under consideration, but rather considers them in relation to their interconnectedness with processes of

17 Regarding her understanding of matter, Barad writes: "In an agential realist account, matter does not refer to a fixed substance; rather, matter is substance in its intra-active becoming—not a thing but a doing, a congealing of agency." (Barad 2007: 151).

knowledge production and also incorporates the capacities to act and interests involved.

As a consequence of their analyses based on science studies, all of the relational approaches discussed here call for a stronger assumption of responsibility in scientific practices when dealing with problematised "environmental" relationships. For environmental sociology, this suggests the need for a much broader engagement with its objects of investigation and the importance of searching for alternative ways of describing problems and finding solutions. Conceptually, relational approaches make it possible to view the social as a complex system with many unknowns, in which the course of action is determined less by linear cause-and-effect chains, overarching ideologies, institutional frameworks or technoscientific control fantasies than by an infinite variety of unpredictable and incalculable interactions and consequences. They open up new possibilities for including the dimensions of complex ecological configurations that have so far been excluded from sociological investigations as material, technical or natural, and more generally, for rethinking this traditional mode of demarcation and a priori differentiation. However, for us, the most important contribution made by relational approaches is the way they facilitate thinking about new approaches to the formative experiences of climate change and pandemics in contemporary society. Relational approaches allow us to consider socio-ecological assemblages in all their historicity, variability and entanglement with specific interests, assertive groups of agents and technoscientific innovations. They thus provide us with scientific terms and concepts to reflect on the misalliances and connections that are not "institutionally sanctified" which exist beyond anthropocentric demarcations and "knowledge-political" divisions, and for a fundamentally different kind of environmental sociology in times of pandemics and global warming.

What students can take away from this chapter:

- Knowledge about the significance and implications of social and, in particular, technoscientific constructions of natural phenomena for society-nature relations
- An understanding of the dual character of society-nature relations
- An insight into the co-evolutionary multidimensionality and socio-technical entanglement of society-nature relations
- An insight into the debate about the agency of human, non-human and other agents
- Knowledge about the differences between dialectical and relational approaches to society-nature relations and human-technology-nature relations

Recommended reading

Callon, M. & B. Latour, 1981: Unscrewing the big Leviathan; or how actors macrostructure reality, and how sociologists help them to do so? *A key text in actor-network theory from 1981 that will teach you the basics of ANT.*

Haraway, D., 1991: Simians, cyborgs, and women: The reinvention of nature *A helpful anthology for anyone wishing to read Haraway's work.*

Latour, B., 2018: Down to earth: Politics in the new climatic regime *A small book that will help you to understand the extent to which the basic political distinctions need to be rethought in order to facilitate a sustainable understanding of the threatened conditions of existence on Earth*.

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Chapter 4: Environmental attitudes and actions

Overview

In this chapter, you will learn how environmental awareness is theoretically conceptualised and how it can be empirically measured. In addition, you will learn about the current state of research on the topic of environmental awareness. You will also learn why environmental awareness does not necessarily lead to environmentally friendly actions and which factors are responsible for this so-called "attitude-behaviour gap". Finally, the chapter sheds light on the extent to which ideas of a good and just social order go hand in hand with corresponding images of nature.

Expressions of concern for the environment seem to be increasing worldwide, both among the population and among political decision-makers, yet at the same time ecological crisis symptoms such as species loss and climate change are intensifying (Richardson et al. 2023). This suggests that awareness about the critical state of the environment has not yet been sufficiently translated into appropriate action. For decades, environmental sociology—often in conjunction with social psychology—has been addressing the questions of how environmental awareness can be conceptualized on a theoretical level, how it can be measured empirically, how different (population) groups perceive and interpret the environment, how environmental awareness and environmental action are connected, and what consequences are produced by the social discourse on environmental awareness. There are two different approaches to the social perception of the environment, which have both been widely used in environmental sociology. Attitudinal and behavioural research, which is committed to methodological individualism, understands the perception of the environment and thus environmental awareness as an individual phenomenon. This means that the central unit of analysis is the individual with their specific attitudes and actions, which are mainly investigated in the context of surveys. Cultural Theory, on the other hand, derives group-related patterns of perception from different modes of social practice. According to cultural theory, the social perception of the environment results not from the aggregation of individual environment-related attitudes, as it does in attitudinal and behavioural research, but from group-specific interaction structures.

In the following two sections, we will look at the social perception of the environment from the perspectives of attitudinal and behavioural research as well as Cultural Theory. In the third section, we will critically reflect on the discourse around environmental awareness and action. To do so, we will adopt a socio-diagnostic perspective to question the function performed by public debates about environmental problems and environmentally friendly behaviour and the consequences they produce.

1. Environmental awareness in attitudinal and behavioural research

Attitudinal and behavioural research assumes that societal interpretations of the environment can be reconstructed entirely from individual, environment-related

attitudes, and that structured surveys of individuals therefore represent the best empirical approach to researching such interpretations. The knowledge thus gained about individual attitudes or actions can then be aggregated into group-related characteristics on the basis of statistical similarities. This results in different environmental awareness and action profiles for different social milieus or population groups. In the following, we will explain the theoretical understanding of environmental awareness found in attitudinal and behavioural research, and present two common instruments for the empirical assessment of environmental awareness. This is followed by a brief overview of the empirical findings from attitudinal and behavioural research about environmental awareness and the relationship between environmental awareness and environmental action.

1.1. The conceptual basis of environmental awareness

A large number of empirical studies have been conducted to assess environmental awareness and the relationship between environmental awareness and environmentally responsible actions. However, the theoretical conceptualisation of environmental awareness in these studies is very heterogeneous and so too is their empirical operationalisation (Best 2011: 241). The lack of a clear conceptual basis means that the results of individual studies can hardly be compared with one another and they often use the term environmental awareness to mean very different things. Thus, environmental awareness is partly conceived and understood as a value system, and partly as an attitude or worldview (Schultz et al. 2005). The following sections provide an overview of the common theoretical conceptualisation of environmental awareness as an attitude and elaborate on the theoretical relationship between attitudes and values.

Values are generally defined as person- or group-specific conceptions of what is desirable (Kluckhohn 1951: 395) or, more specifically, as an enduring belief that a particular course of action or state of affairs is preferable to an opposite course of action or state of affairs (Rokeach 1973: 5). Freedom, equality, safety, independence, cleanliness, helpfulness, love, etc. are examples of values (Rokeach 1973: 28). Values are mostly considered as antecedents of attitudes. This means that it is assumed that certain attitudes regarding an object are derived from and influenced by values. The idea that environmental awareness is based in values has also become widely accepted in environmental sociology (Stern & Dietz 1994; Best & Mayerl 2013). Individual attitudes toward environment-related issues or phenomena are accordingly derived from their (positive or negative) relationship to individual value orientations. So, for example, environmental awareness is associated with a post-material value orientation (Inglehart 1971, 1995).

The term attitude is understood as a psychological tendency to react approvingly or disapprovingly to an object, person, institution, or event (Ajzen 1988: 4; Eagly & Chaiken 1993: 1). In attitudinal research, a three-component model has gained acceptance, according to which attitudes are composed of affective concern (affective component), knowledge about the object (cognitive component),

and intentions to act (conative component) (Eagly & Chaiken 1993)[18]. Environmental awareness as an attitude accordingly comprises affective concern about environmental problems (e.g., anger, fear, helplessness, or hope), knowledge and information about environmental problems (e.g., climate change is caused by humans), and a general willingness to act to remedy environmental problems (e.g., willingness to save energy) (Best 2011: 245).

In most empirical studies on environmental awareness, there is no precise definition of the term "environmental awareness". The same applies to theoretical discussions about the concept (Dunlap & Jones 2002). This is probably due to the fact that the meaning of the term seems clear at first and thus a pragmatic use of the term has prevailed. The following definition by Robert Jones and Riley Dunlap, one of the sociological masterminds of environmental awareness research, has been widely used internationally: "[...] environmental concern refers to the degree to which people are aware of problems regarding the environment and support efforts to solve them and/or indicate a willingness to contribute personally to their solution" (Dunlap & Jones 2002: 485). In the German context, for instance, reference is often made to the classic description provided by the German Advisory Council on the Environment (SRU), which defines environmental awareness as the "realisation that the natural foundations of human life are endangered by humans themselves, combined with the willingness to take remedial action" (Der Rat von Sachverständigen für Umweltfragen 1978: 445). In principle, both definitions are compatible with the understanding of environmental awareness as an attitude. However, if we take the three-component model as our foundation, it is clear that neither of these definitions mention the affective component (Diekmann & Preisendörfer 2001: 102).

1.2. The empirical assessment of environmental awareness

To assess individual attitudes (and value orientations), quantitative empirical social research uses "items", which are often combined to form scales. The term "item" refers to a question or statement on which respondents are asked to state their position. The following statement is an example of an item that is repeatedly used in surveys related to the environment, technology or risk: "Humans have the right to modify the natural environment to suit their needs." Individual attitudes are regarded as latent variables that are not directly observable. Accordingly, they are assessed via items, the answers to which can be assumed to provide information about the respondent's attitude. In order to capture a specific latent variable such as environmental awareness in its different facets, various items can be combined to form a so-called scale. In this process, the different measurements for the individual items are aggregated into one measurement, which is then interpreted as an indicator for the person's attitude.

In the German-speaking world, the general environmental awareness scale by Andreas Diekmann and Peter Preisendörfer (Diekmann & Preisendörfer 2001: 104)

18 While the three-component model views emotions, cognitions, and conation as equally important, recent attitude research emphasises the dominant importance of emotions (Banaji & Heiphetz 2010: 358).

are of particular importance[19]. Internationally, the *new ecological paradigm scale* (NEP scale) created by Riley Dunlap and Kent van Liere is particularly widely used (original version of the scale: Dunlap & van Liere 1978; revised version of the scale: Dunlap et al. 2000). In the following, we will briefly discuss Diekmann and Preisendörfer's general environmental awareness scale and Dunlap and van Liere's NEP scale, as these are common instruments for national and international assessments of environmental awareness.

The NEP scale is not an attitude scale in a strict sense, as it does not take into account the affective and conative dimensions of attitudes, i.e., those related to intentions to act. According to Dunlap et al. (Dunlap et al. 2000), the NEP scale is intended to capture an ecological worldview rather than environmental awareness as an attitude. The items of the NEP scale therefore exhibit a high degree of abstraction. Both Thomas Dietz et al. (Stern & Dietz 1994) and Henning Best and Jochen Mayerl (Best & Mayerl 2013) place the NEP scale in a hierarchy of mental constructs as a mediator between abstract values (e.g., post/-material value orientations) and specific environmental attitudes. The NEP scale is criticised in particular for lacking a clear theoretical basis and thus its role in the interaction of attitudes and values remains vague on a conceptual level. The items of the current version of the NEP scale can be found in Table 1. The respondent's agreement with the individual items is recorded on a five-point response scale (strongly agree, mildly agree, unsure, mildly disagree, strongly disagree) (Dunlap et al. 2000: 433).

Table 1: The NEP scale; source: The NEP statements (items) from Dunlap et al. 2000: 433

The wording of the NEP statements (items)
We are approaching the limit of the number of people the Earth can support.
Humans have the right to modify the natural environment to suit their needs.
When humans interfere with nature it often produces disastrous consequences.
Human ingenuity will ensure that we do NOT make the Earth unliveable.
Humans are seriously abusing the environment.
The Earth has plenty of natural resources if we just learn how to develop them.
Plants and animals have as much right as humans to exist.
The balance of nature is strong enough to cope with the impacts of modern industrial nations.
Despite our special abilities, humans are still subject to the laws of nature.
The so-called "ecological crisis" facing humankind has been greatly exaggerated.
The Earth is like a spaceship with very limited room and resources.

19 Comprehensive information about both scales can also be found in the open access repository for measurement instruments provided by the Leibniz Institute for the Social Sciences (GESIS): https://zis.gesis.org/en.

The wording of the NEP statements (items)
Humans were meant to rule over the rest of nature.
The balance of nature is very delicate and easily upset.
Humans will eventually learn enough about how nature works to be able to control it.
If things continue on their present course, we will soon experience a major ecological catastrophe.

In contrast to the NEP scale, the general environmental awareness scale is an attitude scale in a narrower sense. This means that the individual items assess cognitive as well as affective and conative attitude components. The individual items and their assignment to the attitude components are shown in the following table:

Table 2: General environmental awareness scale; source: Diekmann & Preisendörfer (2001: 104), own translation

Dimension	The wording of the items
Affective	It worries me to think about the environmental conditions, under which our children and grandchildren would probably have to live.
	If things continue on their present course, we will soon experience a major ecological catastrophe.
	When I read newspaper reports or watch TV broadcasts on environmental problems, I get frustrated and angry.
Cognitive	There is a limit to the economic growth that our industrialized world has already crossed or will reach very soon.
	At present, the majority of the population still behaves in a way that is not very environmentally friendly.
	In my assessment, the so-called "ecological crisis" facing humankind has been greatly exaggerated by many environmentalists.
Conative	It is still the case that politicians are doing far too little for environmental protection.
	For the benefit of the environment, we should all be prepared to restrict our current standard of living.
	Measures to protect the environment should be enforced even if this results in lost jobs.

Agreement with the individual items is assessed using a five-point response scale. While the NEP scale focuses on more abstract attitudes toward human-environment relations, the general environmental awareness scale is more specifically tailored towards environmental problems. This is a key advantage for the empirical analysis of the relationship between environmental awareness and environmental action: Since, from a theoretical point of view, values tend to be "action remote" constructs, measuring instruments that focus on abstract values have less

empirical explanatory power with regard to concrete environmental action than more specific attitude scales, such as the general environmental awareness scale (Homburg & Matthies 1998: 126).

1.3. Empirical findings on environmental awareness and environmental action

Environmental attitudes are not uniformly structured in the population, but instead take on group-specific forms. For example, while for some people the protection of rare animal species is paramount, others are more concerned about the effects of climate change. Both represent different variants of environmental awareness. In addition, the significance of different aspects of environmental awareness also changes over time in line with discourses in society as a whole (Radkau 2014). The various instruments used to empirically assess environmental awareness, two of which were presented in the previous section, are each selective, however, as they (can) only cover certain aspects of environmental attitudes. Empirical studies that have measured environmental awareness using different instruments are therefore only comparable to a limited extent. Accordingly, the current state of research is inconsistent and partly contradictory. Internationally, there is an almost unmanageable number of empirical studies, mostly of a quantitative nature, on the topic of environmental awareness and action. Nevertheless, a brief overview of the state of research in different fields of investigation is still worthwhile, as it reveals the central empirical findings as well as the questions that remain unanswered. The following overview, which must necessarily remain cursory due to the large number of studies, focuses on two fields of investigation: a) environmental awareness and group-specific differences in attitudes within Germany and b) international comparisons of environmental awareness and the relationship between environmental awareness, post-materialistic value orientation and economic prosperity.

Although different studies are difficult to compare due to their diverging methodologies and operationalisation of the term environmental awareness, it can be said that environmental awareness has been at a relatively high level within the German population since the 1980s, however with considerable fluctuations over time (Hartmann & Preisendörfer 2021). Also, attitudes toward ecological issues and domain-specific environmental actions vary—sometimes considerably—between social milieus, i.e., population groups characterised by similar value orientations, patterns of action, and social situation (education, income, occupational status, marital status, etc.). The middle-class mainstream, for example, is characterised by below-average environmental awareness and action, while critical-creative milieus are more environmentally aware than average and also prove to be particularly sustainable in their actions (Rubik et al. 2019). In addition to the milieu-specific differences, women also exhibit a higher average level of environmental awareness than men (Kuckartz & Rheingans-Heintze 2006). Furthermore, a positive correlation between formal education and environmental awareness can be seen time and again (Kuckartz & Rheingans-Heintze 2006;). However, it should be noted that the actual carbon footprint in social milieus that are characterised by a high level of education, high income and a high

degree of environmental awareness is usually particularly large (Moser & Kleinhückelkotten 2018). In particular this is caused by the fact that, due to their high level of income, people in those social milieus (can) travel more for pleasure, the amount/quality of technical devices in their households is generally higher and, on average, they have more living space per person.

With regard to international comparisons of environmental awareness, two different theories have been developed that relate to the connection between a country's level of economic prosperity and its population's environmental awareness. The "prosperity hypothesis" (Franzen & Meyer 2010) assumes that the populations in countries with a high level of economic prosperity have higher average environmental awareness, since more people in those countries have a post-material value orientation, which is causally related to environmental awareness. This connection has been empirically demonstrated several times (see, for example, Inglehart 1995; Franzen 2003). Then again, Riley Dunlap and Richard York analysed data from the World Values Survey and found no correlation between prosperity level and environmental awareness. They conclude that environmental awareness has become a global phenomenon that is just as widespread in poorer countries as in richer ones, and interpret this as evidence that disproves the prosperity hypothesis (Dunlap & York 2008). The current state of research does not make it possible to draw any clear conclusions about the global relationship between prosperity level and environmental awareness, so the question of whether the phenomenon of environmental awareness is independent of prosperity cannot be answered conclusively on an international scale.

As we have already seen, there are differences in environmental awareness between different population groups in Germany. The question now arises to what extent this also applies on an international scale. In a comparison of various European countries and the USA, Angela Mertig and Riley Dunlap find only very slight correlations between socio-demographic variables (age, income and gender) and environmental awareness. This suggests that environmental awareness is widespread in all strata of the societies studied and is therefore not a group-specific phenomenon (Mertig & Dunlap 2001). Jochen Mayerl and Henning Best, however, were able to show on the basis of data from the World Value Survey that in poorer countries there is no connection between a post-materialistic value orientation and environmental awareness, but that such a correlation does exist in richer countries. In more affluent countries the level of environmental awareness varies between materialistically and post-materialistically oriented population groups (Mayerl & Best 2018). Thus, again, it remains unclear to what extent population groups within countries differ in terms of their environmental awareness or whether concern for the environment is a generalisable phenomenon.

1.4. The gap between environmental awareness and environmental action

The extent to which a high degree of environmental awareness actually results in environmentally conscious actions is a highly relevant question, both from a sustainable development perspective and from a scientific perspective. First of all, it is safe to assume that a person's mindset has an influence on their actions.

After all, this is one of the central assumptions of attitudinal and behavioural research: Attitudes have an action-guiding and motivating character for planned and deliberately controlled behaviours (Ajzen 1991).

In empirical studies, there is often only a slight correlation between attitudes and corresponding actions. This phenomenon is usually referred to as the *attitude-behaviour gap*. In the environmental field, the gap between environmental awareness and environmental action is particularly pronounced (Kollmuss & Agyeman 2002). The fact that in many cases people do not act according to their environmental attitudes has found its way into many public environmental debates. In such debates references are repeatedly made, mostly in a sarcastic way, to allegorical Green Party voter(s) who take long-distance trips. The empirically observed gap between environmental awareness and environmental action raises the question: To what extent can moral appeals and measures for increasing environmental awareness have corresponding effects on people's actions? In order to be able to answer this question meaningfully, it is worth taking a closer look at the causes for this discrepancy between environmental awareness and environmental action in empirical studies. These are both methodological and conceptual in nature. While the methodological causes are due to problems in the empirical recording of environmental awareness and environmental action, the conceptual causes relate to the theoretical understanding of how action ultimately comes about. The following sections provide an overview of the methodological and conceptual causes of the *attitude-behaviour gap* between environmental awareness and environmental action (Homburg & Matthies 1998: 127f.).

One methodological reason for the weak correlation between environmental attitudes and environmental actions is that in empirical studies attitudes and actions are often assessed at different levels of abstraction. Attitudes are mostly surveyed at a relatively general level, while actions are assessed more specifically. While this makes sense in terms of trying to avoid tautological explanations (e.g., people who intend to purchase a fuel-efficient car in the near future actually do so), when the measurement of attitudes becomes more abstract, the number of possible intervening, situational and moderating variables increases – and the direct relationship between general attitude and specific action becomes more and more lost. So, for instance, a large number of factors play a role in everyday car use (e.g., place of residence, car availability, accessibility and knowledge of alternative means of transportation, motives such as convenience, freedom or safety, etc.), whereby environmental awareness becomes one of many influencing variables.

Another methodological cause is the assessment of patterns of action instead of area-specific actions. In some cases, different types of action are combined into an action index for the empirical analysis. However, in different fields of action people have different (perceived) levels of freedom to act and they view different motives for action to be relevant. This means that for a certain person, separating rubbish may be easy, but saving heating energy may be difficult or not a primary objective because of the presence of small children in the household or because of an automated heating system.

A third methodological reason for the *attitude-behaviour gap* between environmental awareness and environmentally responsible action can be found in the different perceptions that scientists and actors have regarding what "environmentally responsible action" actually means. Actions that scientists classify as sustainable may not be classified as sustainable by survey respondents due to different evaluation standards or information. Of course, the reverse is also true. For example, many people classify regionally produced food as particularly sustainable, although this is not necessarily always the case.

In addition to these three methodological causes, there are three other conceptual difficulties that influence the relationship between attitude and action on environmental issues. First, there is the low significance of environmental awareness for everyday actions. In everyday life, environmentally friendly action plays a subordinate role for many people, since a) other motives for action enjoy higher priority (e.g., convenience) and b) a multitude of (perceived) structural constraints limit their scope for action. In addition, actions in everyday life often occur as bundles, so that the execution of a particular action is linked to a large number of other actions and thus influences them (→ chap. 7 on sustainable consumption). For example, the use of a car for commuting to work often means that trips taken in one's free time (e.g., shopping, sports, childcare, meeting friends) are also carried out by car.

The relevance of routines represents another reason for the low influence of even very pronounced environmental awareness on everyday actions, since routines determine the majority of our everyday actions. The reasons for establishing routines and the purpose of maintaining them are by definition not open to conscious reflection. Accordingly, attitudes and changes in attitudes have no direct influence on these routines. (Not) turning off the light when leaving the room is such a routine, which largely escapes conscious behavioural control in everyday life. Only when such routines are put to the test due to drastic events or profound irritations can they be questioned and re-evaluated in light of individual attitudes. For example, the birth of children often leads to dietary routines being disrupted and changed (Schäfer et al. 2012).

The so-called low-cost hypothesis (detailed presentation → chap. 7 on sustainable consumption) represents a third and final conceptual cause of the gap between attitudes and behaviour. According to the low-cost hypothesis, people only act in accordance with their (environmental) attitudes if those actions do not entail excessively high action costs (money, time, convenience, etc.) compared to other action options (Diekmann & Preisendörfer 2003). Otherwise, their actions are and remain driven by subjective cost-benefit calculations. The low-cost hypothesis can thus explain why environmentally aware people recycle their waste but are much less willing to give up their private cars.

As we have just seen, there are plausible reasons for the seemingly paradoxical *attitude-behaviour gap*. However, although a gap exists in everyday life between environmental awareness and environmental action, this does not mean that environmental awareness and environmental education are irrelevant. That said, the

empirically weak correlation shows that environmental education alone is not sufficient to increase environmentally friendly behaviour among a population. Additional structural barriers that hinder action must also be removed and contexts for action must be organised in such a way that sustainable action becomes the easiest option, regardless of individual motivations. Even if environmental awareness is only one motive among many, it is an additional stabiliser of action. It provides a legitimate reason for environmentally friendly decisions that is comprehensible to many other people, and contributes to the maintenance of sustainable routines. Furthermore, a high level of environmental awareness in the population and the associated sensitivity to environmental problems creates a public climate of opinion in which certain ideas, demands, expectations, visions of the future, etc. can be expressed and are compatible, and this generates public pressure on political decision-makers and companies. Demands that people travel less or not at all by air or that vegetarian days be introduced in canteens would certainly have found hardly any public or political resonance in the 1990s, and not even widespread public outrage.

2. Social order and myths of nature – The Cultural Theory perspective

Whereas attitudinal and behavioural research considers group-specific perceptions of the environment to be the result of the aggregation of individual attitudes, Cultural Theory (Douglas & Wildavsky 1982; Thompson et al. 1990; Douglas 2003 [1970], 2010 [1966], 2011 [1982]) has developed a different approach to the "myths of nature" (as it is called in the language of Cultural Theory). Cultural Theory assumes that group-specific myths of nature originate from the interaction structures of social groups. Thus, it is not individual attitudes that are decisive for the form and characteristics of social perceptions of the environment, but rather the interaction structures in which individuals are embedded and which shape their attitudes.

Cultural Theory has become prominent, especially in the field of social science research that investigates the perception and assessment of ecological risks. The prominence of this approach was boosted in particular by the 1982 essay "Risk and culture: An essay on the selection of technological and environmental dangers" by Mary Douglas and Aaron Wildavsky (Douglas & Wildavsky 1982). In their essay, Douglas and Wildavsky summarise the basic ideas behind Cultural Theory as it relates to (environmental) risks as follows: "[...] the choice of risks to worry about depends on the social forms selected. The choice of risks and the choice of how to live are taken together. Each form of social life has its own typical risk portfolio. Common values lead to common fears (and, by implication, to a common agreement not to fear other things)" (Douglas & Wildavsky 1982: 8).

In the following, we explain the theoretical basis of Cultural Theory: the grid-group scheme. In addition, we will go into more detail about the different myths of nature postulated by Cultural Theory and finally we will summarise the various critiques of Cultural Theory.

2.1. The grid-group scheme

At its core, Cultural Theory assumes that a certain social order ("social environment"), i.e., the structure of social relations within a certain group (e.g., family, organisation, society, etc.), corresponds to certain patterns of orientation ("cultural biases") (Thompson et al. 1990: 1). These cultural biases filter people's attention by structuring perception in such a way that certain situations, events, or developments are framed as problematic and certain solutions appear as legitimate or rational. Social environments and cultural biases constitute each other, or as Thompson et al. put it: "social relations generate preferences and perceptions that in turn sustain those relations" (Thompson et al. 1990: 2)[20]. According to Cultural Theory there are four different types of social environments[21], which are based on two dimensions: "group" and "grid". The term grid describes the degree of social regulation ("individuation"), while group refers to the strength of group ties or degree of social integration ("social incorporation") (Thompson et al. 1990: 5f.; Schwarz & Thompson 1990: 6; Douglas 2003 [1970]: 62f., 2011 [1982]: 190). One pole of the grid dimension describes a social environment in which clearly articulated and distinct classification systems exist and, accordingly, the behaviour of individuals is constrained by strict and explicit rules. The other pole of the grid dimension describes a social environment in which, at best, abstract and thus open-to-interpretation classification systems and rules of behaviour exist. The group dimension describes the degree of group loyalty, i.e., the strength of group ties. One pole represents a social environment in which clear group boundaries are drawn between the group and others, where a high degree of group identification and social control exists within the group and correspondingly strong group bonds prevail. The other pole is characterised by, at best, weak group boundaries and the most extensive absence of social control and group identification, and correspondingly weaker group bonds.

The intersection of the group and grid dimensions creates a scheme with four fields, which is usually used to graphically illustrate the four different types of social environments, which, according to Cultural Theory, are the only forms of social order that can exist in the long term (see Figure 6). Mixtures of these four types of social environments can exist temporarily, but in the long run, it is assumed, they will cease to exist due to their internal contradictions (Douglas 1999: 411). This strict theory that there are only a certain number of different social environments has attracted much critique, since it does not seem very plausible that only four forms of social environments can exist permanently, especially in late modern, pluralistic societies (Johnson 1987). It therefore seems reasonable to conceive of the four types not as real but as ideal types. These ideal types influence cultural biases but are not capable of being completely responsible for their real-world manifestation.

20 Implicit parallels to Bourdieu's concept of habitus can be seen here.

21 Some publications on Cultural Theory assume the existence of five different types of culture (e.g., Thompson et al. 1990), but this is controversial (Mamadouh 1999: 401). For reasons of space, we will only describe the four common cultural types.

The four social environments are mostly referred to as fatalism, hierarchy, individualism, and egalitarianism, and their adherents accordingly as fatalists, hierarchists, individualists, and egalitarians (Thompson et al. 1990: 6f.; Douglas 2011 [1982]: 205ff.).

Hierarchy describes a social environment characterised by strong group ties (+ group) and strict rules regarding behaviour (+ grid). Individuals living in a hierarchical social environment see themselves as subject to strict behavioural control, which is justified by the fact that the stability and well-being of the community can be ensured by adherence to role patterns and the accompanying division of labour. The emergence of problems is attributed to deviant behaviour or external influences. Examples of hierarchical communities are bureaucracies or traditional, patriarchally structured families.

Egalitarianism as a social environment is characterised by a strong group bond (+ group) but unspecific rules regarding behaviour (- grid). Accordingly, there is a high degree of solidarity between egalitarians and at the same time a low degree of behavioural control, since there are hardly any firmly defined role patterns or possibilities for control. In this social environment blame for problems is placed on institutions or the "system", which corrupts individuals. Social movements are an example of egalitarian communities.

Individualism refers to a social environment with weak group ties (-group) and unspecific rules regarding behaviour (-grid). Here, social relationships are organised competitively and the rules of behaviour are negotiable and open to interpretation. In such a competitive social environment, individuals are encouraged to pursue their own benefit in a selfish manner. For individualists, the cause of problems lies in personal misconduct or bad personal qualities or incompetence. Communities organised according to market principles and structures can serve as an example here, even if individualists do show some degree of group identification.

Fatalism is a social environment that is characterised by low group loyalty (- group) but strict rules regarding behaviour (+ grid). Accordingly, fatalists do not see themselves as belonging to any particular group, but are thus also excluded from the groups that determine the rules regarding behaviour. Such rules are therefore perceived as given and unchangeable. If problems occur within this social environment, they are attributed to fate and are accordingly located outside the realm of human influence. By definition, fatalists do not form communities and are therefore largely isolated, so no example of a fatalist community can be provided here.

	- group	**+ group**
+ grid	Fatalism	Hierarchy
- grid	Individualism	Egalitarianism

Figure 6: The grid-group scheme; source: own illustration based on Schwarz & Thompson (1990: 7)

Adherents of these different social environments fight within society for the hegemony of interpretation on how to deal with risks (e.g., air pollution) and which solutions should be considered legitimate and rational (e.g., setting limits for air pollution and monitoring their compliance vs. banning car traffic in inner cities). Within a society, there is a specific mix of egalitarians, hierarchists, individualists and fatalists, which can change over time. The more strongly an individual is attached to a certain social environment, the more strongly they internalise the cultural biases that apply there[22]. The social environments and their adherents exist in parallel because, despite their antagonistic relationship, they each depend on one another in order to legitimise their existence (as separate from the other types), to compensate for their respective weaknesses, or to instrumentalise the other types for their own ends (Thompson et al. 1990: 4).

2.2. Myths of nature

According to Cultural Theory, the social environments described above correspond to certain ways of perceiving nature or "myths of nature", which are shaped by the specifics of the corresponding social environments (Schwarz & Thompson 1990: 8ff.; Thompson et al. 1990: 26ff.). This means that the individual's perception and evaluation of environmental problems is determined by the social environment in which they are embedded. Each individual's perception is to be considered biased in that it tends to justify the preferred social environment or warn against risks to the preferred social environment. Basic assumptions about what is risky, dangerous, sustainable or unsustainable are accordingly always related to social, group-specific patterns of interpretation. For example, for individualists, environmental problems are only relevant if they limit the functioning and the "self-healing powers" of the free market; market-based instruments (e.g., emissions trading) are preferred as solutions to environmental problems. Egalitarians, on the other hand, perceive environmental problems as generally threatening even if they affect only a few members of their group, and typically call for a fundamental change of the "system". A myth of nature from one social environment thus appears irrational to members of other social environments. By linking social order to the perception and evaluation of problems, Cultural Theory takes a social constructivist perspective on nature, according to which society cannot have an infinite number of different myths of nature, but it can have (at least) four different, mutually exclusive variants. The myths of nature are ultimately partial representations of reality.

According to Cultural Theory, individualism corresponds to the myth of a resilient nature ("nature benign"), hierarchy to the myth of a nature that is tolerant within limits ("nature perverse/tolerant"), egalitarianism to the myth of a fragile nature ("nature ephemeral"), and fatalism to the myth of an unpredictable nature ("nature capricious") (Schwarz & Thompson 1990: 4ff.; Thompson et al. 1990:

22 Here, there is disagreement about the extent to which the assignment of an individual to a particular type of social environment is an invariant, permanent characteristic of that person, or whether this assignment is instead context-specific, quasi role-dependent, and also changes over time (Thompson et al. 1990: 265ff.; Mamadouh 1999: 404).

26ff.). Figure 7 shows the location of the myths of nature in the grid-group scheme: The inherent logic of the myths of nature is mostly illustrated with corresponding graphical illustrations.

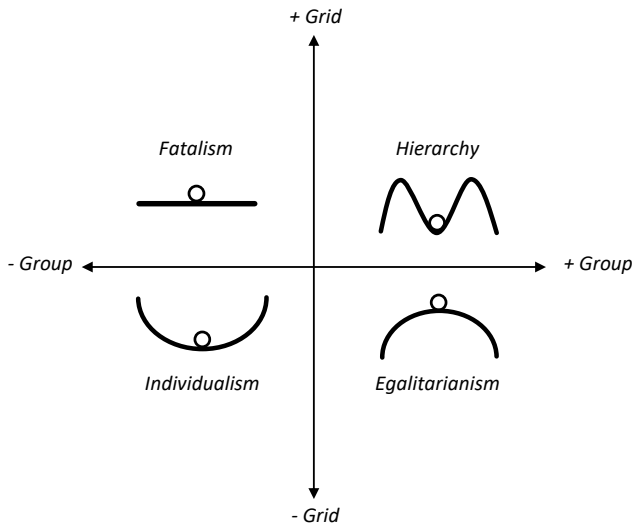

Figure 7: Location of the myths of nature in the grid-group scheme; source: own illustration based on Schwarz & Thompson (1990: 9)

The individualists' myth of nature – **"nature benign"** – frames nature as an unlimited resource that can't really be thrown out of balance by human activities because it is fundamentally stable and robust. Far-reaching human interventions in nature are therefore unproblematic, as these are generally well tolerated and any side effects can be easily remedied with the help of technological progress. This myth corresponds with the market-based, competitive social environment preferred by individualists.

In the egalitarians' myth of nature – **"nature ephemeral"** – nature is perceived as extremely vulnerable and easily thrown out of balance. Their preference for a social environment based on solidarity and free of exploitative relationships is thereby transferred onto how they view humans' relationship with nature. Accordingly, egalitarians seek to avoid significant human interference with nature, especially interference caused by technical progress and economic growth, and to adapt human activity to the limits of nature. If this does not happen, they believe the ecosystem will collapse sooner or later.

The hierarchists' myth of nature – **"nature perverse/tolerant"** – describes nature as a basically robust system that can, however, become unbalanced when overexploited. Accordingly, nature can certainly be used as a resource, but care must be taken to ensure that the stress limits identified by experts are observed. With the help of the right management strategies, nature can be used for human purposes

without any problems. This is in line with the hierarchists' belief that clear structures and control are the best means of stabilising the social fabric.

The fatalists' myth of nature – **"nature capricious"** – ultimately characterises nature as a system that functions according to randomness and chance, or at least according to principles that are not completely accessible to humans. Accordingly, people are at the mercy of nature's whims and cannot consciously influence them either positively or negatively through their actions. This corresponds to the fatalists' belief in fate and their general feeling of powerlessness (Schwarz & Thompson 1990: 4ff.; Thompson et al. 1990: 26ff.).

2.3. Criticism of Cultural Theory

Cultural Theory and its proponents have been exposed to a variety of criticisms over the years, directed against different aspects of the theoretical framework (see, for example, Johnson 1987; Boholm 1996). The most important points will be summarised here very briefly.

On the one hand, critics argue that the theory ultimately does not provide a compelling explanation for why human interaction and social order should be differentiated solely in terms of the group and grid dimensions. They also suggest that these two dimensions are not clearly defined and therefore their meaning remains unclear and vague. Also, the premise that there are only these four types of social environments does not seem to be very tenable, especially since some Cultural Theory researchers later added a fifth type (autonomy) (see, for example, Thompson et al. 1990), while Mary Douglas, the founding figure of Cultural Theory, maintains that there are only four types (Douglas 1999). Moreover, the idea of exactly four types appears to be an oversimplification of social realities, particularly against the background of late modern, pluralistic and functionally differentiated societies.

Criticism is also directed against the assumption that every person is an adherent of a particular social environment. This seems implausible, since individuals are embedded in very different contexts, groups, and organisations and are therefore never consistent in their perceptions and actions across different spheres of life. Thompson et al. emphasise that people only show tendencies towards a certain social environment and the associated cultural biases (Thompson et al. 1990: 265f.), but it remains unclear how these tendencies are supposed to come about.

Another point worthy of criticism is the lack of clear separation between the individual types of social environments. Empirically, it is always possible to find social groups that combine elements from different social environments. For example, there are environmental associations organised according to strict hierarchies that are committed to an egalitarian myth of nature.

Nevertheless, Cultural Theory provides a plausible distinction between different patterns of orientation ("*cultural biases*")—including a theoretical explanation for their occurrence—which has proven itself time and again as a heuristic for empirical analyses. From a pragmatic perspective, therefore, one can state that the

theoretical and argumentative vagueness of Cultural Theory does not undermine its empirical application. Cultural Theory should therefore be categorised more as a heuristic that guides empirical research rather than as a coherent theoretical structure.

In empirical applications, Cultural Theory has repeatedly proven to have explanatory power, even if its explanatory power should not be overestimated (Sjöberg 1998). For example, in line with Cultural Theory, it has been empirically shown that egalitarians are less willing to accept ecological and technological risks than fatalists, hierarchists, and individualists (see, for example, Dake 1991; Peters & Slovic 1996; Steg & Sievers 2000). Climate change scepticism also appears to be less prevalent among egalitarians than individualists (Shi et al. 2015). Cultural Theory is not only useful in empirical analyses of the perceptions and assessments of ecological and technological risks, it also provides a good basis for devising strategies to deal with such risks. Cultural Theory's four myths of nature each represent particular perspectives on risks that hide some aspects and emphasise others. A holistic approach to addressing risks should therefore seek to integrate all four cultural biases so that they complement each other with their respective strengths and weaknesses. Solutions to socio-ecological problems must therefore be developed with the participation of representatives of each of the four myths of nature, so that they are viable for society as a whole. Such solutions are then inevitably not ideal solutions, but instead what are known as "clumsy solutions". However, in view of socio-ecological problems characterised by uncertainty, ambiguity and complexity (e.g., anthropogenic climate change or loss of biodiversity), these are, from the point of view of Cultural Theory, the only viable solutions (see, for example, Thompson et al. 1998; Verweij et al. 2006; Ney & Verweij 2015).

3. Moral appeals to environmental awareness and the problem of responsibilisation

In sociology and beyond, there are voices that critically comment on public debates about environmental awareness and environmental action as well as the corresponding research on these topics. The main argument here is that calls for the population to think and act in a more environmentally friendly way leads to the responsibility for environmental protection and environmental destruction being shifted away from industry and politics and onto citizens, thus partially relieving industry and politics of the burden of this responsibility (Maniates 2001). As a consequence, the problems of unsustainable economic structures and policies become hidden. This argumentation is embedded in a larger discourse around neoliberalism as a political practice, which criticises the fact that since the 1980s the state has increasingly withdrawn from the task of providing public services, that a growing number of areas of life are being organised according to the rules of the market, and that responsibility for societal well-being is increasingly being outsourced to citizens (Harvey 2007). One example of this is the dismantling of local public transport, which is supported and financed by the state. In such cases, the resulting gap is either filled by private providers (as long as they can expect

to make a profit), or it is left to civil society in the form of community buses or neighbourhood-organised driving services to maintain the mobility of population groups such as the elderly or economically deprived families.

In the context of environmental debates, the concept of responsibilisation means that responsibility for environmental protection is (consciously or unconsciously) transferred from collective actors such as the state or companies to individuals, who then try to live up to the expectations associated with the role of environmentally aware citizens (Maniates 2001). Environmental awareness and information campaigns or calls for environmentally aware action can be seen as instruments of such responsibilisation (Shove 2010; Evans et al. 2017). At this point, it is necessary to criticise the fact that such responsibilisation efforts are based on the assumption that individuals have a great degree of freedom in their actions and could act differently (in this case more sustainably) without much effort. This largely ignores the problem that individuals are often "locked into" non-sustainable structures—this is also referred to as "*lock-in*" (Unruh 2000)—and non-sustainable action thus almost always represents the simpler, more obvious and structurally supported option for action (Hinton & Goodman 2010) (→ chap. 7 on sustainable consumption). For example, a high level of unsustainable individual motorised transport is structurally promoted and stabilised by, among other things, correspondingly designed infrastructures (e.g., shopping centres with large parking facilities on the outskirts of cities and in industrial areas) and legal regulations (e.g., rules that stipulate how many parking spaces must be provided on or near new buildings or tax deductions for commuters who use their own cars).

What students can take away from this chapter:

- Knowledge about the theoretical basis of the conceptualisation of environmental awareness
- Knowledge about the empirical assessment of environmental awareness
- An understanding of the complex empirical relationship between environmental awareness and corresponding actions
- An understanding of the connection between different conceptions of nature and social environments (Cultural Theory)

Recommended reading

Ajzen, I., 1991: The theory of planned behavior. *Basic article summarising the theory of planned behaviour as one of the central theories of modern attitudinal and behavioural research.*

Douglas, M. & A.B. Wildavsky, 1982: Risk and culture. An essay on the selection of technological and environmental dangers. *Classic essay on how environmental and risk perception is culturally influenced and a foundational text of Cultural Theory. The grid-group scheme can be seen here in its basic form – it was elaborated even more clearly in later publications.*

Dunlap, R.E. & K.D. van Liere, 1978: The New Environmental Paradigm: A proposed measuring instrument and preliminary results. *Classic article about empirically oriented*

environmental sociology with a particular focus on environmental awareness research. It presents a new empirical instrument for measuring environmental awareness, which was further developed a good two decades later in the article below.

Shove, E., 2010: Beyond the ABC: Climate change policy and theories of social change. *Pointed practical and theoretical critique of attitudinal and behavioural research that identifies the key weaknesses of this strand of research in the field of environmental action.*

Thompson, M., R.J. Ellis & A.B. Wildavsky, 1990: Cultural theory. *Comprehensive overview of Cultural Theory with a systematic presentation and explanation of the grid-group scheme.*

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Chapter 5: Risk and conflicts about risk

Overview

In this chapter, you will learn about the great importance of risks and the contested perception of risks in environmental sociology. You will gain knowledge about various factors that influence risk perception. We will introduce you to Ulrich Beck's (1992) "Risk Society" and Niklas Luhmann's (1989) "Ecological Communication", two classics of environmental sociology and the sociology of risk that approach this topic differently but which are both still relevant today. Finally, we look at the complexity and uncertainty of overarching risk configurations and examine their contribution to the "co-production" of social change processes through conflicts about risk.

Risk sociology is of particular importance in environmental sociology, as it brings together its central questions as if under a prism. It sometimes focuses on individual substances and processes that are associated with potential harm to the environment and people's health, and analyses their social perception, evaluation and regulation. In recent years, for example, not a day has gone by without "carbon dioxide" and "particulate matter" being debated. Both substances are emissions produced by the combustion processes of motor vehicles and heating systems and are subject to international regulation through the use of limit values. Carbon dioxide is held partly responsible for global warming and particulate matter for considerable health risks. The increase in both emissions is largely due to routines and processes that have emerged with industrialised society and enabled growing prosperity for large parts of a growing world population, but have also caused environmental damage and health hazards. Opportunities and risks, desired progress and its undesired side effects are closely related and it is correspondingly difficult and controversial to characterise undesired effects as "risky" or to try and avoid them. It quickly became apparent that the assessment of such risks is influenced by the point of view of the observer, which is affected not only by social and cultural conditions but also by individual cost-benefit considerations and assessments about whether the risks can be controlled, and also that the cycles of attention depend less on the absolute increase or decrease of substances in the air than on their problematisation in the media and politics. "Asbestos", "dioxin" and "plastic waste" have all had similarly problematic careers in sociological research on risks. However, such research is also dedicated to social risks in other areas including international stock market trading, terrorism and pandemics. However, the sociology of risk does not focus predominantly on the variable individual assessment of such risks, but rather on the difficult connection between controversial and uncertain knowledge on the one hand and political conflicts and decisions on the other. Where risk perceptions differ and, for example, there is considerable criticism of expert analyses and their risk assessments (as happened with regard to the potential risks of nuclear energy, biotechnology and mobile phone systems), controversies about risks develop a sub-political potential (Beck 1992). Conflicts about risk call into question the balanced relations of interpretation; they test the limits of the processing capacity of

institutional responsibilities between decision-makers and those affected, experts and laypersons, as well as between different subsystems, such as the economy and health (Luhmann 2017 [1991]).

The way society deals with air pollutants is an example of the interesting sociological dynamics in the "risk society", which, as Ulrich Beck (1992) has pointed out, have become an issue and a problem due to the unintended side effects of successful modernisation: Traffic emissions were never considered desirable, even horse faeces caused social annoyance and the regulation of exhaust emissions has a long history. But the current conflicts over traffic emissions and their effects are not simply the result of an increase in nitrogen oxides, particulate matter, and carbon dioxide. Facts and values become mixed up in the heated debate about the precise identification of substances deemed to be hazardous, how dangerous they are, the places and processes of their formation, possible methods for reduction and avoidance, and assessments of those methods. In the assessment of what is considered appropriate or unacceptable in terms of air pollution control and which forms of national and international regulatory enforcement are legitimate vis-à-vis the groups affected, legal, social, economic and ecological perspectives struggle for priority in the classification of damage that has occurred versus anticipated disasters, and in the field of tension between stochastic assessments versus changes to existing social orders. These political debates about risk have long since led to a reassessment of motorised private transport and threaten a Western icon of freedom, progress and prosperity – and not without further social consequences.

In the sociology of risk, these complex interrelationships are analysed in order to gain a better understanding of the dynamics of valuation and devaluation that are triggered and their significance for further political and socio-technical development. The social sciences are thereby also making their own contribution to risk assessment, risk communication, and risk governance (Renn 2008). In contrast to other disciplines, the focus is not on identifying the risky characteristics of individual products or phenomena or the legal discussion of regulatory options, but rather on the social significance of risk perception and risk communication, their context- and group-specific variability and the consequences of often controversial risk assessments and regulatory approaches. This brings into focus three central ideas or aspects of the sociology of risk that are shared with environmental sociology as a whole: firstly, the focus on conflicts of interpretation, their backgrounds and typical structures; secondly, the significance of these conflicts of interpretation for social self-images and their successive questioning; and thirdly, the erosion of institutional and sociological categories that takes place when dealing with conflicts about risk and the increasingly difficult demarcation of risks in spatial, temporal and social relationships.

This chapter is organised according to these three aspects. In the first section, we deal with questions about risk perception and show the extent to which neighbouring disciplines such as psychology, anthropology and communication studies can be used to identify typical patterns of risk perception and make them useful for social analysis. In the second section, we look at conflicts about risk, the

politics of risk and the social significance of controversial risk assessments from the social theory perspectives of Ulrich Beck, Niklas Luhmann and Bruno Latour. Each of these authors has a different answer to the question of whether and how risk assessments play a socially transformative role, and thereby proposes different consequences for (environmental) sociology. In the third section, we turn to the current risk configurations, which cannot be limited to individual fields of action. Development trends such as progressive mobilisation, digitalisation and resource exploitation do however cause cross-system effects and make an overarching risk policy an issue and problem in global modernity. Finally, we examine the key question of the extent to which the global confrontation with the anthropogenic risks of environmental changes and global warming not only triggers conflicts over nuclear power and transport development, for example, but also drives the search for alternative social models.

1. Risk perception and defining risks

Social science research on risks was established together with environmental sociology at the end of the 1970s as a reaction to the perceived accumulation of environmental disasters, and has been developed across various disciplines. Since its beginnings, it has been concerned with the tension between risk realities and risk perceptions, i.e., the assumption that risks actually exist and their perception-dependent recognition, communication and evaluation. Wolfgang Krohn and Georg Krücken introduce their 1993 anthology on "Risk as Construction and Reality" with the observation that, on the one hand, the increasing use of technology creates an objectively growing pressure to address problems – be it in the form of the failure of high technologies that could lead to catastrophes, or be it in the form of creeping and irreversible hazards, and that, on the other hand, the perception and assessment of technical risks are subject to social and cultural conditions whose change leads to considerable changes in perception and reassessment (Krohn & Krücken 1993: 9). The dilemma is that risks only become a social fact when they are perceived as such; the fact that they are perceived as a risk, however, makes them one. What does this mean?

Terje Aven and Ortwin Renn (2009: 1) describe risk as "the uncertainty and severity" of possible consequences of actions and decisions in relation to something "that people value". Every perception of risk is therefore uncertain and embedded in socio-cultural and ethical evaluation standards. Until the late 1960s, only Romantic poets and groups involved in nature conservation had made a problematic connection between technological progress and its potential to damage the environment. It was only after awareness-raising publications such as "Limits to Growth" (Meadows et al. 1972) and "Silent Spring" (Carson 1962) had sensitised the populations of Western industrialised countries to this connection that chemical and nuclear accidents were assessed as a "typical" consequence of "risky technologies". Krohn and Krücken were consequently able to write about the "failure of catastrophic high technologies" without any further explanation in 1993. In 1993, readers associated "insidious hazards" with many of the man-made toxins found in foods and the environment that are still discussed

today, however their associations were embedded in patterns of appreciation that are quite different to those seen today. Although risks are generally perceived selectively and in accordance with a particular perspective, modern individuals and organisations generally claim to be guided not by imagined but by actual risks. They often refer to a statistical definition of risk, namely the probabilistic model of risk calculation, with which risks are calculated according to the probability of their occurrence and the amount of damage they would cause. The environmental scientists Robert Kates and Jeanne Kasperson made the important conceptual distinction between risks and hazards in 1983 and emphasised the statistical understanding of risk as a specific, quantifying form of perception: "*Hazards are threats to people and what they value and risks are measures of hazards*" (1983: 7027).

The calculation of risk that is oriented towards "measurement" reveals the origin of the concept of risk and its emergence as a specifically modern form of dealing with uncertainty (Bernstein 1996). It was only when the capitalist economic order and the claim to rational calculability gained central importance and superseded the pre-modern devotion to God-ordained or natural fate (a process to which Max Weber devoted much attention) that risks became conceivable as assessable uncertainties that could be subjected to forward-looking calculations. Etymologically, the term probably goes back to the Italian *risciare* in the context of the medieval long-distance trade of northern Italian cities. It denoted the gamble that merchants took when, for example, they equipped a ship and sent it out in the knowledge of numerous dangers such as storms, rot and piracy in order to increase their wealth as much as possible after its fully laden return – or, in the worst-case scenario, to be financially ruined (Bernstein 1996). They thus assessed the probabilities of success and failure individualistically in relation to their own actions—a historical novelty—and soon developed security-oriented expectations by creating forms of mutual insurance in risk-bearing entities with a new forward-looking approach. To this day, this concept of risk forms the basis of the insurance industry and works above all when empirical values about the extent of past damages and the probabilities of occurrence are available and both variables remain small enough to keep the possibility of (financial) compensation open. This concept of risk is therefore not an "objective" risk assessment, but a socio-culturally specific assessment or "construction". It is firmly linked to a certain social order that only includes certain types of damages and ways of dealing with them in its calculations while "externalising" others from consideration, and it forms new kinds of cooperation beyond informal, mutually supportive communities, such as contractually organised insurance companies.

As the following explanations will show, every type of risk assessment already has at its core an idea of how it intends to deal with uncertainties. The statistical concept of risk, which is primarily used in the insurance industry and engineering sciences, serves to either monetise risks for compensation or to make them comparable so that decisions can be made between alternative actions, materials or processes. In principle, probabilistic risk assessment emerges from decision-making situations and does not arise as a reaction to the mere possibility

of conceivable (negatively assessed) events. Depending on the data situation, the quantifying type of assessment makes a valuable contribution to well-founded decision-making as long as the perceived risk is not so great that it is judged to be completely unacceptable, and as long as avoidance of the risk is actually possible. In the 1980s, however, repeated chemical accidents and the first major accidents at nuclear power plants led to a spread of critical assessments among parts of the population related to technology and the environment, in the light of which these technologies appeared to be too risky and therefore unacceptable, but also avoidable. Protests began, giving rise to environmental movements, green parties, the identification of an expert/layperson dilemma and an intensified social science debate about the different perceptions of risk.

As politics was entirely focused on technological progress and technology-savvy attitudes with positive perspectives on the controllability and cost-benefit ratio of technologies prevailed, particularly among highly qualified developers and users, risk research initially focused on the task of how to support "more rational" risk assessments and create acceptance among the population. The so-called "deficit model of risk communication" emerged, which assumed that "laypeople" were sceptical about technology because they lacked the specialist knowledge of experts. However, if they were provided with "correct" information about risks, they could correct their "incorrect" risk perception in favour of greater acceptance of technology (Irwin & Wynne 1996). In the period from 1970 to 1990, risk research was initially dominated by psychological approaches focusing on the individual, then by more anthropological and communication theory-based approaches focusing on "newspaper-reading communities".

The first studies focusing on the problem of acceptance of the potential risks of new technologies came from engineers themselves. Chauncey Starr (1969) went beyond probabilistic assessments to include social contexts by comparing scepticism towards novel risks (rail transport) with already accepted probabilities of harm from known risks (smoking) and from this derived "*how safe is safe enough?*" for public risk assessments. He came to the conclusion that risks are considered acceptable if they are associated with a good degree of benefit, if they are entered into voluntarily, if only limited harm is foreseeable, and especially if the death rate does not exceed that of common diseases (Fischhoff et al. 1978: 128). Psychologists continued his investigation in the "psychometric paradigm" of risk research with quantitative attitude studies in order to measure the supposed acceptability of risks in surveys and experiments. In doing so, they also focused on qualitative assessment characteristics, such as perceived catastrophic potential, lack of control or the distribution of costs and benefits, as well as other factors that influence risk perception (Slovic 2000). The large number of subsequent studies were disappointing with regard to the search for clear, stable conditions of acceptance. Instead, they highlighted the context- and object-specific variability and temporal changeability of risk perceptions now labelled as "social", but did not allow any predictions regarding acceptance due to the manifestly uncertain connection between attitudes and actions. With its focus on individual risk

perception, psychometrics can contribute little to sociological risk research on different risk assessments and their significance.

Mary Douglas and Aaron Wildavsky (1982) addressed the issue from the perspective of cultural anthropology and developed a cultural theory of risk perception (→ chap. 4 on environmental attitudes and action). According to this theory, it is not individual assessments but collective "ways of life" and forms of social organisation that determine risk assessments. They assume that in modern societies subjects do not form their own judgement for every possible risk. Rather, they orientate themselves according to superordinate worldviews, which are essentially characterised by two dimensions, namely a stronger or weaker orientation towards compliance with norms and rules in dealing with hazards, and stronger or weaker group ties (*grid-group scheme*): While strong group ties (*high group*) require a high degree of collective control, this is less pronounced in social groups with weak group ties – instead, those social groups have a stronger emphasis on personal responsibility. A way of life with a strong focus on structure and norms (*high grid*) is oriented towards permanent hierarchies and rules, whereas a low-grid way of life tends towards an egalitarian order. According to cultural risk theory, in political conflicts over risky technologies and environmental damage, people in milieus with a strong orientation towards rules and a high level of group loyalty ("hierarchists") rely on state and norm-based regulation, while members of more market-based and individualistic milieus with a weak orientation towards rules and group ties ("individualists") rely on the independent actions of individuals. So called "fatalists" with a strong focus on rules but weak group ties tend to hold back apathetically due to their low conviction regarding the effectiveness of action, while so called "egalitarians" can be expected to scandalise and politicise environmental damage and technical risks due to group pressure and their focus on solidarity.

With its heuristics of typical attitudes towards risk, cultural theory of risk was considered superior to psychometric risk research for a number of years because it enabled a supra-individual reconstruction of the connection between risk perception and the preferred (political) social order, which appeared to be confirmed in some case studies. It showed the extent to which controversies about risk are a) linked to questions of political (not legal) regulation, and b) can be attributed to institutional differences in the way uncertainty is dealt with. On the other hand, this approach lacks any reference to different risk characteristics and processes that could be used to assess the appropriateness or plausibility of risk perceptions or explain the temporal and spatial differences in the occurrence of protest or acceptance, which, from an expert perspective, are often unexpected. These risk perception reference points are also ignored in the integrative analyses related to communication theory that were subsequently developed, which suggest the *social amplification or attenuation* of debates about risk are a result of psychological, social, institutional and cultural processes and their interactions. Instead, these analyses focus on the heuristics of individual information gathering and processing and work with multi-level concepts.

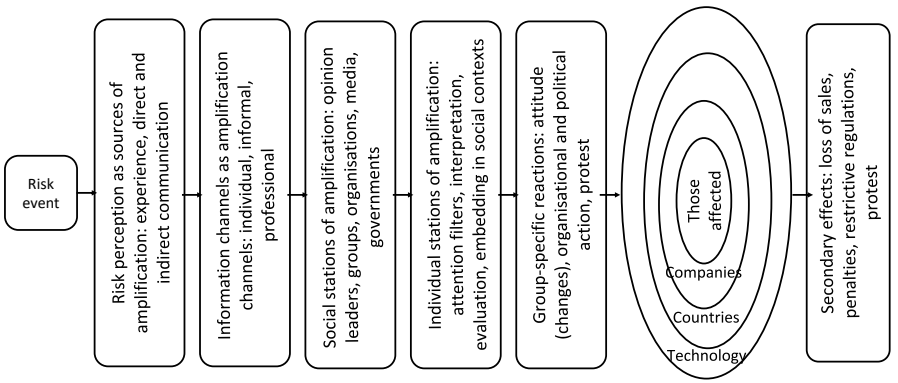

Figure 8: Simplified illustration of the effects of social amplification; source: own illustration based on Kasperson et al. (1988: 185)

The central assumption of this perspective is that the evaluation of hazards interacts with psychologically and socially based attention filters as well as with institutional and cultural forms of risk processing, and that this results in a strengthened or weakened perception of risk (Renn et al., 1992). In terms of communication theory, in this approach "risks" (*risk events)* send bundles of signals consisting of technical and symbolic information to the public via various stations of information processing and evaluation, through which they are influenced by communication from politics, science, mass media, opinion leaders, peers, etc. In the individual recipients, who in turn filter and select, the decoded risk signals lead to behavioural reactions that firstly indicate a strengthening or weakening of the original message and secondly trigger secondary effects such as arousal or (institutional) adaptation measures that contribute to a further escalation or de-escalation. On the input side the approach is implicitly based on hazards identified by experts, which on the recipient side, filtered through the various communication stations, are translated into individual perceptions of risk with corresponding reactions. These perceptions no longer correspond to the expert assessments, but rather "overestimate" some risks (protest against nuclear power), while "underestimating" other sources of risk (smoking). From today's perspective, it is remarkable how the authors differentiate the public's assessment from that of experts, viewing public assessments as a "product of intuitive bias and economic interests as well as cultural values" (Kasperson et al. 1988: 178) while expert assessments are seen to virtually coincide with "the risk" itself, so that experts formulate objective assessments supposedly free of these influencing factors.

It was precisely this assumed difference between experts and laypeople that became increasingly problematic politically, especially when the first nuclear power critics emerged from among the experts themselves and became "counter-experts". The public no longer unquestioningly accepted expert judgements as better and "rational" in political debates. The dispute over technology policies and

their hidden side effects and the public debates on risk assessments and risk management increasingly called for more comprehensive and context-sensitive risk assessments than the probabilistic calculation of risk can provide. In view of the various approaches and case studies, Sheldon Krimsky and Dominic Golding (1992) clearly oppose the deficit model of risk communication in their anthology on social theories of risk. In view of the complex interrelationships between direct and indirect technological consequences and risks and their inconsistent assessment, it is necessary to take a closer look at the construct of "scientific objectivity" and to conceptualise a differentiated "social rationality" on a par with expert rationality. Since every social construction and assessment of "risk" is inevitably embedded in contexts of experience and assessment with specific mixtures of knowledge and ignorance—and there is no difference between experts and other actors in this regard—Sheila Jasanoff views risk assessment per se as a political experiment in which other context-related, for example social and ecological assessment criteria must be taken into account in addition to technical criteria (1999: 150). This is where the sociological theory of risk makes a useful contribution.

2. The sociological theory of risk

As we have seen, risks are constructed in social contexts according to the relevant attention filters and this has different consequences for their assessment. These constructed concepts of risk can be statistical or orientated towards controllability, adjustability, familiarity or other standards, which in turn generate secondary effects, for example for insurability, acceptance, and legal and political containment. According to the model of the social amplification of risk, these "ripple effects" trigger social learning and adaptation effects that impact existing institutions (e.g., risk management) or business areas. In risk theory, the secondary effects are viewed as "side effects" (Beck 1992) or as "re-entry" (Luhmann 2017 [1991]). The sociological theory of risk thus faces the challenge of being confronted less with direct risks in the form of estimated environmental and health hazards or unintended technological consequences than with indirect consequences and interactions, namely the institutional modifications and political changes triggered by risks. This is aggravated by the fact that risks often do not become visible and socially virulent in the direct context of their emergence, but are temporally, spatially and socially displaced and delimited (Beck & Kropp 2007).

2.1. The risk society by Ulrich Beck

Politically, it soon proved to be much easier to lose than to gain trust when dealing with debates about risk, partly because possible hazards and incidents that have occurred are perceived, communicated and observed differently in a sensitised environment, which then calls into question the competence and trustworthiness of existing institutions and actors. In the risk society described by Ulrich Beck (1992) in his widely acclaimed book—which was published a few weeks after the reactor accident in Chernobyl—chemical and nuclear pow-

er accidents, emissions, food scandals and the potential risks of biotechnology lead to a politicisation of the institutional and political status quo, as well as biographical risks that arise in the wake of progressive individualisation, professionalisation and emancipation. Above all, Beck observed a loss of confidence in the ability of existing institutions to solve problems, particularly in science and politics, and more fundamentally an erosion of the consensus on progress and growth of the post-war years. In the years that followed, he observed how the established starting points for attribution, evaluation and differentiation were disintegrating far beyond risk management and how a political arena of conflict was forming instead. The rampant consequences of the Chernobyl disaster and later of Fukushima, but also the financial crises, the risks of climate change and the countless accidents and disasters on the world's oceans first undermine the control fictions of the responsible experts and then call into question central industrial/modern solutions and distinctions in science and politics, for example national vs. global, nature vs. technology, useful vs. dangerous. For Beck, "living in world risk society means living with ineradicable non-knowing" (2008: 115), because more and better knowledge does not reduce the uncertainties. Instead, more science and new and better expertise always produce new risk theories and hypotheses – especially on the expert side. The considerable consequences of risky technologies such as chemical accidents, nuclear disasters or asbestos prove to be almost uninsurable, often affect populations in other places and at later times and were soon no longer regarded as special cases, but as the new reality of the world risk society under conditions of reflexive modernisation (Beck 2008, 2016). In reflexive modernity, social change is no longer driven by the desired achievements of "progress", but by its unintended side effects and their social problematisation and politicisation.

For Beck, the increase and intensity of debates about risk heralds a new age which, unlike the "first" (industrial) modernity, is not centrally defined by the distribution of positive gains in the wake of further modernisation. Rather, the unbounded, "cosmopolitan" contemporary society is slipping into a "second" modernity due to unintentionally co-produced uncertainties, risks and damages – i.e., "modernisation risks" (Beck 1992). This society is losing recourse to sectoral and national solution schemes precisely because it is forced to deal with the unintended side effects and uncertainties of successful action. Charles Perrow (1999 [1984]) describes a new kind of "normality" of disasters, which owes itself to the ever-closer networking of socio-technical developments and creates risks particularly where there is a high level of complexity and close coupling due to uncontrolled functional entanglements. This new normality contributes to an experience of the present as a form of "organised irresponsibility", according to a bon mot by Beck, whose institutional order is no longer able to cope with the globally produced socio-technical interlinkages.

According to Beck's risk theory, the rapid production of secondary consequences, which do not stop at national borders, leads to a reflexive self-confrontation with modern societies and their promises of order and security. These consequences reform and (unintentionally) revolutionise the institutional foundations and social

relations, but take the form of successive change ("metamorphosis") rather than a radical revolution (Beck 2016). Global risks therefore not only bring about the possibility of new types of disasters, but also new types of opportunities to create structures and institutions for cooperation across borders that do more justice to the everyday experience of globality than nationalist container thinking. They create new reflexivities for the self-application of the promise of modernisation, partly with existing institutions (democracy, capitalism, globalisation), for example in the form of a "cosmopolitan community of risk", and partly through institutional change towards cosmopolitan forms of solidarity. The generalised awareness of risk creates a connection with transnational public spheres that spans different locations and species. Beck (2016) expected the development of these transnational publics and their associated demand to have a say to lead to the emergence of the necessary global climate movement, such as the Fridays for Future movement of global youth initiated by Greta Thunberg in 2018. A social self-examination that reforms the institutional foundations of modernity and fundamentally questions its modes of representation is, of course, only possible if alternatives are conceivable and options are recognisable. In this respect, as is often pointed out, the earlier risks of famine or war may have been greater, but they were, as we will come back to in a moment with Niklas Luhmann, attributed to external fates, not internal decisions. Societal development itself was not placed in the context of political options as a risky problem related to control, as is typical for risk societies, where it subsequently causes conflicts and debates about the right way to deal with optionality.

In contrast, these days the perceived risks of developments within society, which are often triggered by science and technology, lead to environmental and technological conflicts in which the underlying definitional relationships become contentious (→ chap. 6 on the environmental movement and environmental conflicts). Ulrich Beck therefore considered risk politics to be the socially consequential debate about whose perception of risk can prevail, which scientific and legal criteria it is based on, and which liability arrangements, costs and compensation claims will result. The reflexive learning of consequences, with which foreseeable damage such as the ecological and health consequences of traffic emissions are processed, politicises the validity of political control, the way responsibility is organised, and the appropriateness of the underlying "definitional relationships" against the background of a flexible space that also makes other understandings of risk, responsibilities and decisions conceivable. Thus, for Beck, risk is "a socially constructed and staged phenomenon through and through in which some have the capacity to defi ne risk and others do not" (Beck 2008: 142).

2.2. Risks and ecological communication in the work of Niklas Luhmann

It is precisely this difference between decision-makers and those affected that is central to the work of the second most important sociological risk theorist, Niklas Luhmann (Luhmann 1989, 2017 [1991]). Unlike Beck, the development of Niklas Luhmann's theory is not based on an increase in new types of hazards, but on an increase in social debates about risk, in the course of which the social problems

of decision-making behaviour change fundamentally (Luhmann 1993: 131). As is usual in Luhmann's systems theory, his analysis of society deals exclusively with communication as a mode in which societies reproduce themselves (*autopoietically)*. Possible "environmental changes", however, lie in the environment of these communications that are orientated towards social reference systems, which they only observe self-referentially: "The system introduces its own distinctions and, with their help, grasps the states and events that appear to it as information. Information is thus a purely system-internal quality" (Luhmann 1991: 18). In this respect, Luhmann views the starting point of statistical and psychological understandings of risk as a self-referential observer construction that says more about the perspective of its users than about the underlying problem.

For him, the concept of risk refers to the historically recent phenomenon of making decisions about the future in the present on the basis of probabilities, which inevitably influences the interests of others. Decisions communicated as "risky" divide social relations into "decision-makers" and "those affected" and, against the backdrop of potentially catastrophic effects, create a reduced willingness to accept risk among those who see their future prospects affected in one way or another. Socially, the question of "who or what decides whether (and within which material and temporal contexts) a risk is to be taken into account or not" (Luhmann 2017 [1991]: 4), becomes central. The sociologically relevant concept of risk therefore does not problematise the "certainty" or "uncertainty" of contingent cases of damage or their avoidance, which itself involves a risk, but rather whether the damage can be attributed to a decision. For Luhmann, the antonym of risk is therefore danger. In contrast to dangerous natural or everyday events that are attributed externally or to oneself, controversies about risk focus on possible damage that is attributed to the decisions of others. The term risk becomes politically explosive as a "second-order observation", i.e., when critical publics criticise the observation criteria that are guiding the actions of decision-makers.

For Luhmann, controversies surrounding risky technologies and their ecological consequences indicate the emergence of a new kind of problematisation of the indeterminacy of the future, against the backdrop of larger decision-making spaces. Due to the social demands of welfare states, the management of controversies can no longer be justified by recourse to economic calculations and existing regulatory norms, but instead raises the question of how far society can establish itself in its environment through its own operations and justify the acceptance of risks. From this perspective, for Luhmann the risks perceived by some people become dangers facing other people who were not involved in the decision and cannot control the decision criteria (Luhmann 1993). The further apart the social groups of decision-makers, beneficiaries and those potentially affected are, the greater the conflicts that can be expected in the political system. It is interesting that Luhmann chooses the same starting point for his analysis of the social significance of conflicts about risk as the pragmatist John Dewey (1996 [1927]) by focusing on the tense relationship between "decision-makers and those affected" in relation to the future options for action of third parties. Whereas in Dewey's case the

direct and indirect effects of decisions at the expense of third parties can lead to the formation of a public sphere and, with successful communication, also of a "large community", Niklas Luhmann (Luhmann 2017 [1991]) fears that explicit risk communication is more likely to fail, as it cannot transcend divergent observational perspectives and instead structurally reproduces the discrepancy between decision-makers and those affected and their divergent risk situations. Another phenomenon leads him to judge attempts to defuse conflicts about risk through communication or participation as useless (Luhmann 2017 [1991]): The enormous complexity of modern dangers, their barely controllable socio-technical interactions and their ecological effects universalise concern on the one hand and make causal attribution to individual decisions difficult on the other, as illustrated by climate change.

In this respect, Ulrich Beck and Niklas Luhmann agree in their observation that interlinkages with serious consequences are increasing as a result of advancing technological possibilities, the potential risks of which can no longer be dealt with through the normal operations of modern industrial institutions (Kropp & Wagner 2005). For Beck, this is the starting point for the emergence of institutional reflexivity, but also for unavoidable controversies about which problem-solving strategies are available for dealing with the consequences of modernisation and its potential threats, and how they can be implemented in a democratically legitimate way. Ortwin Renn (2008), drawing on a co-operation with the International Risk Governance Council (2005) and a number of colleagues, proposes a risk governance procedure in which the complexity, uncertainty and ambiguity of the risks in question are first determined in order to then provide analytical and deliberative recommendations for the risk assessment, communication and prevention, which take into account the various perspectives. For Beck and Renn, communication lays the foundation for the development of suitable forms of response. For Luhmann, on the other hand, the threat lies more in an exaggerated public discussion about new types of risk situations, as this "fear communication" threatens to destabilise social systems.

2.3. The co-production of risky networks in the work of Bruno Latour

Bruno Latour (2007) has developed a completely different perspective on risks. He also assumed that the number of interlinkages with serious consequences is increasing, but did not separate the social space in which they are debated from that of their production and spread. In his perspective, the production and communication of risks such as particulate matter, nuclear radiation and novel viruses takes place in principle in the same "social" space, because materialities and perceptions are mutually dependent. However, there is not just one social space, but several different ones in which networks of actors bring about cultures of nature as assemblages in different ways. This can be illustrated, for example, with the different mobility worlds in European countries, Africa or the USA, in which diesel vehicles feature different technical equipment and are also perceived differently. Latour (1993) thus described nature and society as a hybrid network, which only modern epistemology separates into nature (danger) – society (polit-

ics) – technology (risk), but in which these dividing lines are blurred by the results of the increasing linking and mixing of all elements.

Latour therefore viewed the dualistic "separation" between natural and technical objects on the one hand, and political and social objects on the other, as a modern delusion. It is maintained discursively and epistemically through corresponding practices of "purification", for example through the dominant distinction between social and natural sciences and between social risk perceptions and the technical risk reality. At the same time, however, this is contradicted by the practices of permanent and ever faster mixing and the resulting new hybrids between the fields labelled nature, politics, and technology. This is why, for example, societies before and after their electrification and also those with or without nuclear power plants are fundamentally different, because they each form different "collectives" with their own associations between human and non-human beings in socio-technical networks. In these networks, it is above all the scientifically and technologically produced "quasi-objects"—a concept developed by Michel Serres (2007: 224ff.)—that make a difference by creating links with all their consequences (side effects) and stabilising a new order. Non-human knowledge objects, i.e., physical things and materialities such as nuclear power or particulate matter, circulate as effective artefacts or "actants" in the actor networks and become reference points for human, but also non-human actions, which they simultaneously change in an interactive way: They are "quasi-objects" because, as agents and mediators of action, they expand the spectrum of relevant actors (Latour 2005: 76, 238) and initiate modifications in the social world of associations. Climate and health-related emissions and the practices, controversies and arenas of negotiation centred around them are a fine example of this, as are viral epidemics. In all cases, quasi-objects, in the form of electricity, atoms, emissions or a severe acute respiratory syndrome (SARS), transform the socio-technical networks from which they emerge and the social orders that have made them possible. They transcend distinctions and overcome demarcations such as national or sectoral boundaries of responsibility (as per Beck), and do not even stop at subsystemic references (as per Luhmann). Anyone talking about particulate matter cannot do so without addressing combustion engines, traffic, mobility constraints, and patterns of settlement. Anyone dealing with the dangerous spread of corona viruses must take into account today's globally networked society and the specific nutrition, health and mobility routines of different groups, including their technological equipment. However, this hybrid activity fails to achieve a disciplinary, purifying understanding of risks as either entities described by the natural sciences or constructs observed by the social sciences. For although "risks" such as particulate matter and global warming are always "*simultaneously real like nature, narrated, like discourse, and collective, like society*" (Latour 1993: 6), only partial facets ever come to light, for example calculated probabilities from a technical perspective, controversial perceptions from a social science perspective or problematisations of organised regulatory requirements from a management perspective. The production of ontologically and epistemologically mixed forces and realities goes unrecognised.

In contrast, Bruno Latour shifted the focus anthropologically to a "social history of things and a 'thingy' history of humans" (1999: 18). He thus directed his attention to the consequences of the many quasi-objects created in the course of modern technological science in new socio-technical networks, which he understood as assemblages of epistemic practices, materially instituted possibilities for and constraints on action, ecological risks, economic interests, and unwanted emissions. In these assemblages (for example around particulate matter), properties, effects, interests and developmental trajectories interact in relational interrelationships that also involve the perspectives from which they are described. For this reason, from Latour's perspective, the conceptual distinction between risk and risk perception does not do justice to the problem. Rather, the extent of the long chains of mediations through objects of any nature", beyond their abbreviated and extraterritorial representation as "environmental problems" or "climate change", only becomes apparent through the reconstruction of the controversies surrounding these "constructs" (Latour 2005).

Instead of carving up the actor networks (e.g., of traffic emissions) in order to understand them or describing them from only one perspective, the aim should be to trace all those involved and the social materiality of their interrelated interactions and characteristics. It then quickly becomes clear that the very definition of particulate matter is location-based and cannot be separated from location-based models about the "current state" and the "desired state", in which modes of transport, transport users, settlement patterns, economic constraints, local preferences and fears all play interdependent roles. According to Latour (2018), by looking at these assemblages from a "terrestrial" perspective, which is understood as being spatially and materially connected to all variety of things as acting beings (2018: 91), it is possible to see that "modernity" has by no means liberated people and dominated nature, but instead become entangled in mutually constructed and competing nature-culture relationships with new dependencies, which are now under threat on planet Earth. Latour argued that in the Anthropocene, the Earth system ("Gaia") reacts to the risky quasi-objects and repoliticises its networks in a "new climatic regime" (Latour 2018). From this perspective, there are no "external" places of cognition from which "global environmental change" as a whole or even an individual risk would become "objectively" visible, since the various cultures of nature are themselves contested, relational, and unstable. In view of the uncontrolled proliferation of risky things such as particulate matter and carbon dioxide, however, whose threatening existence has long since become a political issue, it is high time to explicitly design new procedures with mindfulness and caution (Latour 2004), in which the already assembled collectives analyse the controversies surrounding their composition and the resistance of those involved. The aim of such a "parliament of things" would be to carefully consider and examine which new arrivals (for example, self-driving cars with all their consequences) should be associated as participants in a "life terrain" (such as urban or rural spaces) and which, in favour of the existing actors, should not (Latour 2004). In the next section, we look at the entanglements resulting from the "new risks" that would be involved in such new procedures.

3. The criticality of new types of systemic risk situations

The spatial, temporal and social extent of risky interrelationships, which are held responsible for problems such as anthropogenic climate change, pose challenges for risk theory due to their complexity and are also important topics among various bodies in business, politics and the public sphere. On the one hand, these interrelationships attract attention due to an understanding in welfare state societies that collective threats to the common good that are attributed to decisions require not only appropriate risk management but also justification. On the other hand, the spatially, temporally and sectorally fluid nature of risky developments creates conflicts that stem from the different assessment perspectives of potential winners and losers, and are exacerbated by the different assessment contexts, places and times. In addition, there is even less cognitively clear knowledge and normatively unambiguous assessment criteria available for the multi-perspective assessment of risks that affect various systems. For example, assessments of the opportunities and risks arising from the future possibilities of biotechnology, digitalisation and robotisation vary greatly from group to group and depending on where they are viewed. This diversity of assessments is further amplified by the fact that each evaluation cannot be based on experience and the side effects of the opportunities and risks are temporally delayed, emerge in other areas or affect other social groups. Christoph Lau (1992) described as "new risks" those hazards which, as mixed forms, can be traced back to human "acceptance", but which, as unintended "natural disasters", cannot be specifically attributed to anyone and remain "in many ways unspecified" (1992: 239). The inability of new risks to be socially attributed elevates them to the status of natural hazards to a certain extent, but at the same time problematises the rationality of the modernisation process from which they emerge, and specifically the responsibility and fairness of scientific, economic and political action related to risks.

These new types of risks, whose negatively assessed consequences can hardly be limited to specific damage categories and whose effects jump from one system to another and ultimately affect entire societies, have been referred to in risk research as "systemic risks" (Renn & Klinke 2004) following an OECD report on "*emerging systemic risks*" that was published in 2003. Unlike conventional risks, their negative direct and indirect effects extend far beyond the contexts in which they arise, transcend national borders and areas of responsibility, and can lead to unforeseen market collapses, trade conflicts and the loss of institutional trust and capital value – just as particulate matter, for example, first jeopardises health, but then also the car industry and the politicians perceived as responsible. Almost all "ecological risks" are to be regarded as systemic risks because their effects interact, are simultaneously felt economically, ecologically and socially, and cannot be limited in terms of time, space, and society. Climate change makes this abundantly clear.

Systemic risks have three central characteristics (Renn 2008): They exhibit considerable complexity due to their underlying, highly interconnected problems; the assessment of their negative, cross-sectoral effects is accompanied by immense uncertainty; and they pose assessment problems, as their hazardous effects are

viewed negatively but their emergence is due to contexts that are assessed positively overall, such as individual mobility, globalisation, and economic growth. As a result, the concept of systemic risks focuses less on individual risks (illness, poverty, accidents) and more on their embedding in civilisation's risk complexes and their cumulative disaster potential (infrastructure failure, pandemics), which results from precisely these developments. As such, investigations into systemic risks tend to focus on global supply chains, densely populated areas, large-scale technological infrastructure systems and their ever-closer internal linkages and ever more extensive external networks. These in turn fulfil precisely the characteristics that Charles Perrow (1999 [1984]) identified as particularly catastrophic, namely close linkages with complex functional restrictions. The risks associated with global networking and entanglement, which transcend system boundaries, are therefore perceived as almost uncontrollable. They arouse individual and collective concern that is reinforced by the media and, conversely, they lead to an increased awareness of risks and security, which, in organisational terms, is countered by only very limited risk management mechanisms. This reinforces the dynamic identified by Beck and Luhmann that socially internalised risks, i.e. risks attributed to decisions, are creating ever greater mitigation tasks for the institutions perceived as responsible – tasks which they are less and less capable of carrying out. It is quite obvious that social forms, institutions and procedures are required to overcome the unbounded primary and secondary effects of systemic risks. Science, business and politics are faced with the challenge of developing new procedures to make the internal production of risks and uncertainties acceptable, without being able to precisely name who the new procedures will be directed at and the causal contexts.

Against this backdrop, forms and procedures for dealing with systemic risks in society emerge in two fundamentally different ways. From a sociology of risk perspective and in accordance with the work of Ulrich Beck, we differentiate between a "knee-jerk" approach and a "reflexive fiction of responsibility" approach. On the one hand, there is an increasingly strong individualisation of risks that is taking place rather reflexively and unconsciously – individuals are made responsible for avoiding risks even though the complex causal conditions systematically overstretch the individual's ability for risk control. One example of this is to demand a change in individual nutritional or mobility behaviour in response to climate change, even though climate change cannot be curbed at an individual level but instead requires a system-wide change. Regulatory responses that make drivers or product liability responsible for "networked" goods such as self-driving cars or software applications appear similarly powerless, as does the nationalisation of responsibility in times of pandemics. On the other hand, deliberately reflexive procedural proposals are developed that conceptually aim to deal institutionally with the complex cause-and-effect chains, the categorical forms of uncertainty, and interpretative evaluation variance and ambivalence. An example here is the previously mentioned multi-level and participation-orientated concept of risk governance (IRGC 2005); a similar example is the older, much-cited ideas of Silvio Funtowicz and Jerome Ravetz (1993) about "post-normal science". According to them, when decisions about risks need to be made and the facts are uncertain,

the figures are disputed, but the potential for damage is high and therefore the statistical risk calculation fails, preparations for the decision-making should be organised with broad participation of those potentially responsible, accountable and affected – instead of relying solely on disciplinary expertise and stochastic assessments. Such concepts are well-meaning and frequently quoted, yet in reality there is usually a lack of institutions that could guarantee the implementation of the required procedures, and furthermore it remains unclear what kind of potential for risk control these discursive procedures can ultimately have in the face of the challenges posed by systemic risks. The new types of risk are products of socio-technical networking that span different organisations and sectors in divergent living and economic environments, and, as such, they generally evade isolated control and regulatory efforts. Accordingly, in a recent paper with Roger Strand, Funtowicz revises the approach and instead argues in favour of directly addressing the lack of capacity to act by gradually initiating solutions that are anchored in current knowledge and oriented towards humane living conditions and testing them in ways that are appropriate for the respective context (Funtowicz & Strand 2011).

But how will it be possible in the future to ensure socially acceptable, experimental or institutionalised risk management for those network-like infrastructures on whose functioning modern life and economic activity depend so extensively that they can be referred to as "public service" structures? Their "vulnerability" has received growing attention under the abbreviation CRITIS (critical infrastructures), partly as a result of armed conflicts, but above all because they are increasingly digitally controlled (Graham 2010; van der Vleuten et al. 2013). Critical infrastructures such as water and energy supply systems, transport networks and internet and communication networks form the backbone of modern and, above all, urban lifestyles. They extend across national borders and at the same time are subject to increasingly fragmented forms of management and responsibility that are organised partly by the private sector and partly by the state. Their increasing size and interconnectedness are thus contrasted by the highly fragmented approaches used to manage them. Also, the resilience of critical organisations that operate these infrastructures is considered essential to modern societies. As a result, several European directives have been aimed at coordinating critical infrastructure protection (CIP), but these have always been overtaken by the possibilities of cyber-physical attacks faster than they could be established. The European Parliament and the Council of the European Union define critical infrastructures as "an asset, a facility, equipment, a network or a system, or a part of an asset, a facility, equipment, a network or a system, which is necessary for the provision of an essential service" (European Parliament & Council of the European Union 2022: Article 2, 4). The functioning of infrastructures can be restricted, disrupted or collapse completely as a result of deliberate acts of terrorism, natural disasters, accidents, negligence, computer problems, cyber hacking, criminal activities, excessive complexity and system failure as well as the failure of other infrastructure systems.

An interruption to the energy supply, the likelihood of which has risen sharply due to the increasingly heterogeneous supply landscape and its transnational organisation, has direct consequences such as the failure of transport systems, traffic lights and locking systems, internet and communication facilities, right through to water supplies. Alarmed by large-scale power failures that affected entire countries in Europe in 2003, 2005 and 2006, which were the result of chain reactions caused by weather-related or organisationally induced technical disruptions, European countries have drawn up national and international precautionary measures and strategies for cooperative prevention and management. In doing so, they are also grappling with the "vulnerability paradox", namely that a country whose supply services are expected to be good is shaken all the more strongly and profoundly by failures because individuals and organisations rely on their functioning and have no backup plans. For this reason, the strategies formulated in various places for dealing with critical infrastructures require the development of a 'risk culture' suited to the complexity, vulnerability and networked nature of large-scale infrastructure systems. This requires appropriate measures for cross-sectoral and open risk communication, as well as cooperation and the strengthening of self-protection and personal responsibility. In reality, however, crises continue to be dominated by nationally and regionally compartmentalised approaches, top-down communication geared towards appeasement and technical clarification, one-sided problem definitions, mutual attributions of blame, and a general lack of clarity as to what is considered vulnerability and who should and can assume responsibility for which areas with which measures and resources and when (van der Vleuten et al. 2013). The interdependencies highlighted on the previous pages and the difficulty in allocating decisions in the face of overlapping impacts and problems have hardly been addressed to date, nor has the fact that poorer and vulnerable population groups are particularly affected by infrastructure failure.

It is also becoming increasingly clear that ensuring the secure functioning of cyber-physical systems in particular places high demands on risk management; in these systems, digital, mechanical and organisational components interact in the management and control of complex infrastructures, such as today's mobility systems and smart cities. In a comparison of national strategies for cybersecurity, the OECD (2012) emphasised that *cybersecurity* is understood in very different ways. However, it is unanimously agreed that ensuring the security of critical infrastructures requires holistic approaches in which economic, social, educational, legal, technical, diplomatic, military and computer science aspects must be taken into account, and that sovereignty considerations of a technical and organisational nature are also becoming increasingly important. The characteristics of systemic risks—complexity, uncertainty and assessment ambivalence—obviously play a major role in connection with the digital transformation. The mixtures of cyber-physical arrangements, with their interdependencies that cross national boarders, sectors and areas of responsibility, are categorically difficult to grasp and therefore lead to conflicts about risk at the organisational and national levels. These conflicts have already become apparent, for example, in the discussion about the approval of Chinese providers for the 5G network in Europe, and

involve a far-reaching socio-technical restructuring of modern societies. This once again highlights the fundamental characteristics of the politics of risk, namely the unequal and conflict-ridden struggle over which and whose rules, interests and resources determine the identification of risks, which forms of risk management can be derived from this, and which potential changes can be implemented as a result.

4. The relationship between global environmental risks and large-scale technical systems

Environmental sociology and the sociology of risk are closely linked: Global environmental changes are primarily perceived as risks for the lifestyles of individuals and societies, and for the functioning of modern market economies and the social order. They are dependent on social attention filters, drive social forms of reaction and, as environmental disasters, have the potential to change modern society's self-image and dominant economic and governance forms – sometimes disruptively, sometimes insidiously. As a field of social science, the sociology of risk has long focused on investigating and explaining conflicts of interpretation, while paying comparatively little attention to the change and spread of new types of risky situations.

However, in order to do justice to the socio-technical configurations of the 21st century, research in this field must engage more closely with the dynamics of the various social, technical and ecological perspectives and how they relate to each other. Accordingly, in their article "*Things are different today*", Renn and his colleagues (Renn et al. 2019) focus on the challenge of dealing with internally complex microdynamics and critical macrodynamics and their external interactions with various system environments in relation to global (financial market) risks. The authors apply their thinking to global environmental risks and, due to their catastrophic potential, also include disagreements about alternative future developments, non-linear development dynamics, tipping points and complex feedback processes with a strong focus on quantitative modelling, in order to make the outcomes of serious risks conceivable – from the failure of systemically relevant subsystems to complete system collapse.

In view of the unsustainability of the world's currently unstoppable growth trajectory, social polarisation trends and the crisis of liberal democracies, there are certainly plenty of reasons for taking a closer look at the complex interactions of interconnected risks. When dealing with global warming and its various direct and indirect, often non-linear effects, it is not possible to separate "risk realities", "risk perceptions" and "risk dimensions". Instead, it is necessary to conceptually and methodologically assess the interdependencies and interactions between the ecological and societal, technical and social, organisational and financial, political and cultural aspects of risk assessment and risk management. In the age of the Anthropocene, air quality, soil, climate, collective lifestyles, infrastructure systems, information technology control systems, agricultural and construction technologies and many other components interact ever more closely with each

other. As such, thinking in terms of stable categories of investigation is an illusion that can only be remedied by a new epistemology – also for risk research (Latour 1996). A new epistemology could also make other social futures conceivable (beyond the narrow view of market societies), so that corresponding transformations can be explored.

What students can take away from this chapter:

- An understanding of what is meant by risk from a sociological perspective
- Knowledge about which factors influence risk perception
- Knowledge about different risk theories
- An understanding of how risks are politicised in society
- Knowledge about what is meant by systemic risks

Recommended reading

Beck, U., 2008: World at risk. *An updated version of Beck's classic "Risk Society". This book provides a broad overview of the political dynamics of globalised risk societies and their conflicts of interpretation.*

Funtowicz, S.O. & J.R. Ravetz, 1993: Science for the post-normal age. *A much-discussed contribution on the appropriate form of science in risk societies.*

Luhmann, N., 1989: Ecological communication. *A key work of the sociology of risk that can also be read for an introduction to Luhmann's systems theory.*

Perrow, C., 1999 [1984]: Normal accidents: Living with high-risk technologies. *Surprisingly topical when it comes to understanding how disasters arise and are processed in high-tech societies.*

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Chapter 6: The environmental movement and environmental conflicts

Overview

In this chapter, you will learn why social conflicts arise about how we treat and relate to nature and what forms these conflicts take. You will learn about different theories that are used to explain the success or failure of social movements and you will become familiar with the history of the environmental movement. You will learn how the environmental movement's perceptions of nature-related problems have changed over time and which socio-structural qualities characterise the environmental movement. Overall, you will develop an understanding of the extent to which the environmental movement has changed the organisation of society-nature relations.

In recent years, increasing concern about climate change and its impact on current and future societies has become an important motive for young people in particular to get involved in socio-political issues. The climate movement is one of the most influential social movements of the last decade. The climate movement thus joins a history of social movements that have attempted to change social conditions. The French sociologist Alain Touraine described social movements as the central driver of the transformation of post-industrial societies (Touraine 1981). This assessment may seem exaggerated to some people. However, it is undisputed that social movements such as the women's movement, the civil rights movement, the peace movement, the labour movement and, last but not least, the environmental movement have changed our society. The history of the environmental movement dates back to the late 18th century: Concern for nature has its roots in the cultural era of Romanticism in Europe, which occurred in the late 18th and early 19th centuries (Radkau 2014). Romanticism developed as a countermovement to the experiences of the Enlightenment, urbanisation and secularisation and was against processes that Max Weber described as the "disenchantment of the world" (Weber 2015 [1919]: 30). Contrary to the claim that nature could be mastered through science and technology, the Romantics attributed nature with subjective qualities and emphasised the spiritual connection between humans and nature (Safranski 2014). Based on these roots, the environmental movement has developed into a key social movement of our time – the sociologist Manuel Castells even described it as one of the most influential: "If we are to appraise social movements by their historical productivity, namely, by their impact on cultural values and society's institutions, the environmental movement has earned a distinctive place in the landscape of human adventure" (Castells 2010: 168).

Before we take a closer look at the environmental movement, let us first clarify what is meant by social movements in general and by the environmental movement as part of the so-called new social movements in particular. Friedhelm Neidhardt and Dieter Rucht define social movements as social entities consisting of interconnected individuals, groups and organisations that – more or less based on collective feelings of identity – express protest through joint actions in order to change social or political conditions or to counteract impending changes (Rucht

& Neidhardt 2020: 839). Although organisations can be part of social movements, a social movement is not an organisation per se, but rather a network. According to Neidhardt and Rucht, social movements differ from organisations such as associations, clubs or parties in three respects: Firstly, there is no clearly attributable membership. For example, it is not possible to clearly determine when a person can be labelled as belonging to an environmental movement. Secondly, social movements do not have a clearly structured division of tasks and roles. For example, social movements do not have a public relations department or an elected or appointed board, but this does not mean that there are no leaders or people who fulfil certain tasks. However, this is more situational and less formalised. Thirdly, social movements rely on the intrinsic motivation of their followers to be able to act. Unlike companies, public authorities or associations, they cannot secure commitment through financial resources (Rucht & Neidhardt 2020: 840f.). In the relevant literature on social movements, the term "new social movements" is used to characterise a qualitative change in the orientation of social movements that took place primarily in the 1960s and 1970s. While the driving force behind the labour movement (an "old" social movement) was class antagonisms and the associated demand for redistribution and material gain, the new social movements are oriented towards other areas of conflict. Their demands are aimed at changing society towards a more peaceful (peace movement), more gender-equitable (women's movement), more environmentally friendly (environmental movement), etc. society. Questions of material redistribution tend to take a back seat (Yearley 2005: 11; Della Porta & Diani 2015a: 4).

According to the above definition, the environmental movement is a social movement that focuses on environmental problems (Rootes & Nulman 2015: 730). The specific problems can be diverse: for example, people protest against waste incineration plants or nuclear power, or in favour of animal rights and climate protection. Accordingly, it makes sense in principle to speak of environmental movements in the plural, even if the environmental movement is sometimes referred to in the singular in order to emphasise commonalities between the individual strands or to point out genealogies. In the following, we will refer to the environmental movement or environmental movements, depending on the context.

This chapter is organised as follows: In the next section, we take a closer look at the concept of conflict in general and environmental conflicts in particular, as environmental conflicts of all kinds are the environmental movement's central areas of action. We then provide an overview of the most important theories of social science movement research in order to provide an idea of how social movements can be approached analytically as an object of investigation. Building on this, we explain the history, the changing worldviews (later referred to as frames), and the main structural features and effects of the environmental movement. Finally, we provide a brief outlook on current developments in the field of environmental movements and environmental conflicts.

1. The environment as an area of conflict

In the course of progressive social modernisation[23] it is becoming more and more clear that nature cannot be regarded as external to society – it is increasingly impossible to maintain the artificially drawn boundary between society and nature (→ chap. 1 introduction). For example, plants become social products due to genetic modification; where the natural environment begins or ends is negotiated in every planning process. So, if nature is not regarded as external, unchangeable and predetermined, then it is hardly surprising that ecological issues are politicised and the subject of social conflict (Sutton 2007: 112). In particular, the perception and politicisation of the unwanted side effects of industrial and scientific/technical processes and other processes of social development and modernisation have triggered environmental and technological conflicts since the 1960s and are regarded as a central impetus for the emerging environmental movement. The sociologists Ulrich Beck and Anthony Giddens have comprehensively addressed and analysed these developments (Beck et al. 1994; Giddens 1990) (→ chap. 5 on risk and conflicts about risk).

As conflicts are a central feature of societies, sociology has always been concerned with them and analysed their consequences for social change. Karl Marx, one of the founding fathers of sociology, is one of the most prominent figures in this field. Modern conflict sociology has its origins in the conflict theories of Ralf Dahrendorf (Dahrendorf 2011 [1992]) and Lewis Coser (Coser 2009 [1956]). Under the influence of Talcott Parsons' structural functionalism, which focused on social consensus, stability and the establishment of order, the sociological mainstream considered conflicts negative and dysfunctional until the 1950s (Saretzki 2010: 35). Ralf Dahrendorf and Lewis Coser succeeded in freeing the concept of conflict from this negative charge by working out that conflicts do not necessarily have a disintegrating effect, and can even stabilise social order and contribute to social progress (Bonacker 2005: 12f.). As with many of the main concepts in sociology, there is no standardised definition of the concept of conflict, as it varies with the theoretical perspective being used to assess conflict phenomena. However, the concept of conflict can be roughly defined as follows, loosely based on Thorsten Bonacker: A conflict is a social phenomenon characterised by the interaction of two or more conflicting parties with different, usually opposing interests and goals (Bonacker 2005: 14f.). Accordingly, the environmental movement and issue-specific environmental movements are often one of the conflicting parties in environmental conflicts. Environmental conflicts articulate opposing ideas about the distribution of environmental impacts, resources (areas of land, sinks, sources), environmental protection costs, etc., but also fundamentally different values about the relationship between humans and the environment, humans and animals, and even competing versions of the truth (Kraemer 2008: 221ff.; Bogner

23 The concept of social modernisation describes the mutually dependent processes of structural change involved in the transition from traditional to modern societies. These structural changes include, for example, urbanisation, industrialisation and later tertiarisation, rationalisation, scientification, secularisation and individualisation (Zapf 1994: 18f.).

2014). Three central types of conflict can be identified: Conflicts of interest, value conflicts and knowledge conflicts.

According to Klaus Kraemer, conflicts of interest are based on competing interests and expectations related to the utilisation of certain environmental functions. The most important environmental functions are the source and sink functions. The source function refers to the utilisation and/or consumption of natural resources (e.g., oil, water, wood, etc.); the sink function refers to the environment's capacity to absorb pollutants and waste (e.g., forests as CO_2 reservoirs, landfill sites, nuclear repositories, etc.) (Kraemer 2008: 221f.). For example, conflicts can arise over the use of the finite resource of oil or over the use of a certain area as a landfill site or local recreation area. It should be noted that scarcities (e.g., in the case of oil) or absorption capacities are also socially constructed and subjectively perceived, i.e., they do not necessarily correspond to physical conditions. This already points to the role of values in environmental conflicts.

Environmental value conflicts, on the other hand, are primarily fuelled by the questions of which forms of environmental use are considered legitimate, which environmental interventions are considered (too) risky (e.g., genetic manipulation), which environmental conditions are worth preserving and what degree of effort is justified for achieving this (Kraemer 2008: 229). Unsurprisingly, in answering these questions different values and worldviews come into conflict with one another. Competing understandings of nature and incompatible ideas about nature and the organisation of human-environment relationships play a decisive role here (→ chap. 2 on the social construction of nature), as do society-nature relations and their transformation (→ chap. 3 on society-nature relations).

While conflicts of interest are caused by competing usage claims and value conflicts by different normative ideas about how to manage environmental goods and services, knowledge conflicts are about the quality and situatedness of environmental knowledge. Knowledge conflicts revolve around key questions such as: "Which knowledge is the true knowledge? How can this knowledge be determined? And how reliable are the respective knowledge claims?" (Bogner 2014: 124). This involves mutually exclusive truth claims and their (scientific) justification. Examples of knowledge conflicts include disputes about risk, such as conflicts over the assessment of the risks of nuclear energy or genetic engineering, but also conflicts of interpretation about climate change and the appropriateness of various measures and courses of action. In knowledge conflicts, expertise and counter-expertise are typically pitted against each other and thus also different scientific approaches, paradigms and convictions (which are in turn determined by competing values, among other things).

Since environmental problems usually become visible and understandable through a scientific approach, many conflicts in which environmental movements are involved are knowledge conflicts. However, it is obvious that the three types of conflict overlap and can only be separated from each other at an analytical level. In this mixed situation, environmental movements represent specific ideas about society-nature relations, which will be considered in more detail in the course

of this chapter. Ultimately, these conflicts always feature different worldviews, because environmental problems and risks are always identified on the basis of values, different scientific approaches and/or competing usage claims, or are selected as problem or conflict areas with disputed truth claims.

2. Theories of social movements

Research on social movements is a separate, interdisciplinary field of research that is located at the interface between political science and sociology (overviews of the theories of social movements and the current state of research can be found here: Della Porta & Diani 2015b, 2020). Numerous theoretical approaches have been developed to analyse the emergence and progression of social movements. This chapter does not have sufficient scope to provide a comprehensive overview of the current state of knowledge and the full theoretical repertoire of this area of research. Therefore, we will only provide a cursory overview of the most prominent theoretical approaches in order to demonstrate how the social sciences approach social movements as a research subject.

Resource mobilisation theory, the theory of political opportunity structures and framing theory form – as Donatella Della Porta and Mario Diani put it – the core of the "classical agenda" of research on social movements (Della Porta & Diani 2015a: 5). In short, the research programme on social movements encompasses both theoretical and empirical work on a) the organisational and entrepreneurial preconditions for the mobilisation of collective action (resource mobilisation), b) cultural meaning-making with regard to the reasons, strategies, goals and identities of social movements (framing) and c) the possibilities and limits of collective action resulting from the structures of the respective political system (political opportunity structures).

2.1. Resource mobilisation theory

While research on collective action has long emphasised the irrationality and spontaneity of mass phenomena, following on from Gustave Le Bon's work "Psychology of Crowds" (Le Bon 2009 [1895]) (Mertig et al. 2002: 465), the theory of resource mobilisation is the first to take a different approach (McCarthy & Zald 1977). This theory emphasises the planned, rationally calculating aspects of actions and decisions in the context of social movements. Bob Edwards and John McCarthy differentiate between five types of resources that social movements can mobilise and use strategically to achieve their goals: material (money, premises, equipment, etc.), cultural (symbols, videos, magazines, specialist knowledge about how to organise a demonstration, etc.), moral (legitimacy, solidarity, sympathy, prominent supporters, etc.), human (manpower, leadership skills, individual experience, etc.) and socio-organisational resources (infrastructure, social networks, etc.) (Edwards & McCarthy 2004: 125ff.). The importance of resources is emphasised because "dissatisfaction with the status quo" is not a sufficient condition for protest and its success or failure: Without staging that effectively attracts media attention, without material and moral support and social networks, the

current Fridays for Future movement would not have been able to become so enormously significant. Just because a certain group is dissatisfied with a certain situation does not automatically lead to the emergence of a successful social movement. Rather, social movement organisations or even individual movement entrepreneurs must have or be able to acquire relevant resources and be able to use these resources in a targeted manner to mobilise protest (Rucht & Neidhardt 2020: 857). In resource mobilisation theory, the type and scope of available resources becomes the central explanatory variable for the decisions and actions and ultimately the success or failure of social movements (Della Porta & Diani 2020: 15).

2.2. Framing

Framing theory, on the other hand, places the socio-cultural definition of problems and their resonance at the centre of the analysis of social movements. It draws on Erving Goffman's work "Frame Analysis: An Essay on the Organization of Experience" (Goffman 1974), in which the concept of the frame is developed as a central element for the interpretation of social situations and thus for interpretative sociology. Goffman uses the concept of frames to describe a collective, mostly unconscious organising principle for everyday experiences (Goffman 1974: 22) that enables people to interpret everyday situations and act meaningfully in them. In Goffman's words, a frame "allows its user to locate, perceive, identify, and label a seemingly infinite number of concrete occurrences defined in its terms" (Goffman 1974: 21).

In the field of research on social movements, perspectives that emphasise the importance of interpretative processes have existed since the late 1960s. However, it was not until the 1986 publication of the article "Frame Alignment Processes, Micromobilization, and Movement Participation" by David Snow and his colleagues (Snow et al. 1986) that this focus on the embedding of individual values and interests in superordinate interpretative frameworks gained greater significance (Snow 2004: 386). Framing theory (for an overview see: Snow 2004) takes a social constructivist perspective and focuses on the collective processes of meaning-making and definition that are necessary to legitimise the actions of social movements for their members and ultimately for society as a whole. Three types of frames are of particular importance here: diagnostic, prognostic and motivational frames. Diagnostic frames serve to identify the causes of certain grievances. They provide a definition of the problem in which perceived injustices play a major role and certain actors or groups of actors are assigned the roles of victims or culprits. Prognostic frames contain the description of a solution to a problem and are used to formulate goals for action. They indicate what needs to be done with regard to possible desired and undesired events. Prognostic frames are often derived from the diagnostic frames and are therefore limited by them. Motivational frames comprise a vocabulary of motives for action (e.g., urgency, dangerousness, necessity, etc.) that are intended to incentivise action (Benford & Snow 2000: 615ff.). Framing processes also serve the formation of collective identities by offering overarching interpretations, formulating orientations for action

and lending greater significance to individual convictions. This defines who you are and who is to be regarded as an opponent and for what reasons.

2.3. The theory of political opportunity structures

Peter Eisinger introduced the concept of political opportunity structures to research on social movements in his 1973 essay "The Conditions of Protest Behavior in American Cities" (Eisinger 1973). At its core, the theory of political opportunity structures (for an overview see: Kriesi 2004) assumes that political opportunity structures are the decisive factors influencing the course and success of social movements (Kitschelt 1986: 58). While the framing theory and resource mobilisation theory focus on the internal conditions of social movements, the theory of political opportunity structures focuses on the external conditions within which social movements emerge and act. From this perspective, the decisive factor is the degree of openness or closedness of a political system, influenced by the degree of its democratisation, but also, for example, by the extent of its federal decentralisation; the stability or instability of political structures; the assertiveness of political elites; the availability or lack of alliances and support groups (Rucht & Neidhardt 2020: 858). In addition to such political opportunity structures, discursive opportunity structures (primarily the media) also play an important role. A social movement's opportunities for action are significantly influenced by its access to the media system and the way its actions are reported, as well as the conditions of digital public spheres (Kriesi 2004: 86; Della Porta & Diani 2020: 224ff.). The theory of political opportunity structures thus emphasises the importance of structural configurations that influence the frequency of protests, the type of protest (e.g., violent or peaceful) and the success of protests. For example, social movements have a greater chance of success if there is a free and diverse press landscape and a broad spectrum of competing interest groups with which alliances can be forged (Rucht & Neidhardt 2020: 858).

3. The structure and progress of the environmental movement

As already mentioned, it is not possible to speak of "the environmental movement" in a strict sense; there are various environmental movements with different emphases and locations. Nonetheless, there are uniform elements in this diversity, which become clear when we look at the historical development of environmental movements. The following overview of this movement's development over time and its changing structures and focal points also provides insights into the changes that have occurred in relation to the social construction of nature (→ chap. 2 on the social construction of nature).

3.1. A brief history of the environmental movement

As already mentioned at the beginning, Romanticism, with its emotionalised, romantic and aesthetic perception of nature (Brand & Stöver 2008: 220), formed the ideal basis for the nature conservation that emerged in the 19th century. An unease with industrialisation and its consequences for nature gave rise to the desire for the – at least partial – preservation of the "sublimeness" of natural land-

scapes. The main demand of conservationists initially related to the establishment of nature reserves (Rucht & Neidhardt 2020: 847). One particularly influential organisation in this context is the Sierra Club, which was founded in the USA in 1892 and was dedicated to the protection of the wilderness and the establishment of national parks. The Sierra Club still exists today and claims to have 3.8 million members[24]. On the threshold of the 20th century other issues came into play, such as air pollution control, animal protection and a particularly strong push for bird protection that originated in England (Radkau 2014). In this early phase the environmental movement, which strictly speaking could be characterised more as a nature conservation movement, was largely politically neutral, if not apolitical, and its demands were quite reserved. With the outbreak of the First World War in 1914, the Second World War that soon followed and the phase of European reconstruction that began in 1945, environmental issues initially receded into the background of public attention across all countries (Mertig et al. 2002: 450). Humanity turned its attention to more pressing problems.

The origins of the modern environmental movement, which was only loosely linked to the preceding (and comparatively conservative) nature conservation endeavours, lie in the USA at the end of the 1960s and beginning of the 1970s. After the Second World War, optimism about progress weakened significantly in the 1960s and ecological problems gained greater attention. There were three main reasons for this (Kern 2008: 104f.): Firstly, numerous regional citizens' initiatives emerged that opposed the construction of roads, dams, airports, open-cast mining and deforestation – a development that was likely nurtured by the general social climate of protest. Secondly, a public debate about radioactive environmental contamination from nuclear bomb tests began, primarily fuelled by the peace movement. Thirdly, the increasing use of risky technologies in the 1950s and 1960s led to more and more environmental problems. In this context, Rachel Carson, an American biologist and science journalist, became an important spokesperson for the environmental movement with her book "Silent Spring", published in 1962. In it, Carson describes the devastating consequences of herbicides and pesticides for flora and fauna and the ecological balance. No less influential was the study commissioned by the Club of Rome[25] on the state and future of humanity, published in 1972 under the title "Limits to Growth". Based on computer simulations, the authors of the study came to the conclusion that with continued population growth and corresponding industrialisation, environmental pollution, food production and the exploitation of finite resources, the planetary limits to growth will be reached within a hundred years (Meadows et al. 1972: 23). Both publications became widely known in Western Europe and North America and thus also sensitised politicians to environmental issues. The focus of the environmental movement thus shifted in the 1960s and early 1970s away from the "old" nature conservation issues towards a problematisation of the negative side effects of technical and economic progress and growth. Joachim

24 See here: https://www.sierraclub.org/about-sierra-club, checked on 03.04.2024.

25 The Club of Rome is an association of experts founded in 1968 to address issues relating to the future of humanity and sustainability.

Radkau describes the period between 1965 and 1972 as the "Ecological Revolution" (Radkau 2014) in which an enormous mobilisation for environmental issues took place on the basis of a new frame of the environmental movement (Mertig et al. 2002: 450). This ecological revolution was initially driven primarily by local citizens' initiatives, which campaigned for an improvement in living conditions in the neighbourhood (Brand & Stöver 2008: 224). Larger organisations only gained increasing influence in the following period.

In the 1980s and 1990s the institutionalisation of the environmental movement continued to progress. Around the world, cross-sectoral cooperation between states, companies and environmental protection organisations to tackle environmental problems and adopt environmental policies became established under the heading of "governance". Environmental protection organisations were accredited as formal partners in more and more international consultations (e.g., UN climate conferences) (Brand & Stöver 2008: 230). At the same time, the environmental movement turned its attention to issues of environmental justice, particularly in the USA. This made the environmental movement compatible with movements critical of globalisation that problematised the consequences of neoliberal globalisation, particularly for the Global South (Kern 2008: 108), and also helped the environment movement to grow its international network. At the end of the 1990s and beginning of the 2000s, some authors note a decline in the dynamism of the environmental movement or even problems finding new adherents. Many young people preferred to get involved in the more active and more visible movement critical of globalisation, which certainly took up environmental problems, but did not make them a priority (Brand & Stöver 2008: 243). With the emergence of global climate movements, above all the youth protest actions of Fridays for Future, this trend has reversed in recent years and people are once again protesting in favour of climate protection measures, sometimes in more radical and confrontational movements such as Extinction Rebellion, which use civil disobedience to force governments to take measures against climate change, species loss and environmental destruction. The threat to the foundations of a liveable future has contributed to a far-reaching mobilisation of both younger and older population groups around the world.

Both the early conservation-focused environmental movement as well as the new environmental movement that emerged in the late 1960s and early 1970s were, in line with the theory of resource mobilisation, always able to mobilise extensive material (e.g., financial donations from supporters), moral (e.g., sympathy from large sections of the population), human (e.g., a large number of scientists who supported the environmental movement with their expertise) and socio-organisational resources (e.g., alliances with other social movements such as the anti-nuclear movement). In terms of the theory of political opportunity structures, the responsiveness of Western governments, social elites and international organisations (e.g., the UN) to environmental problems also contributed to the institutionalisation of the environmental movement over the decades. It has also already been mentioned that the dominant frames – i.e., the patterns of perception and interpretation described by the framing theory explained above – have changed

throughout the history of the environmental movement. In the following, we will take a closer look at the frames that can be identified.

3.2. Frames of the environmental movement: Conservation, environmental protection and ecology

The fact that the central frames of the environmental movement have changed repeatedly over the course of its history does not mean that one frame has always been replaced by another. The different frames coexist, sometimes overlap and are of varying importance in different parts and phases of the environmental movement (Mertig et al. 2002). In the relevant literature, a distinction is usually made between the three frames of conservation, environmental protection and ecology (Mertig et al. 2002; Rootes 2004; Giugni & Grasso 2015).

At the beginning of the environmental movement nature conservation was the dominant theme. It still exists today and mainly revolves around the preservation of natural landscapes, species protection and the avoidance of overusing natural resources. Since, historically, conservation endeavours usually related to relatively narrowly defined, locally confined problems, solution strategies in this frame were often clear and obvious (e.g., more environmentally friendly management of a certain forest or designation of a certain area as a national park or nature reserve) (Mertig et al. 2002: 451f.). In the 1960s, or at the latest at the beginning of the 1970s, a new frame became established with the emergence of the modern environmental movement: the environmental protection frame. In this frame, the focus on the local preservation of nature was replaced by a much broader perspective on environmental problems. The impact of environmental problems on quality of life, human health and societies as a whole came to the fore, e.g., in relation to the risks posed by pesticides and herbicides. The diagnoses and definitions of problems are more complex in the environmental protection frame, the cause-effect relationship is often not clearly identifiable and is conveyed in a more technological and scientific manner. Although the problematised phenomena can often still be localised (e.g., oil spills), they are regarded as fundamental problems that occur everywhere and at all times and can have far-reaching indirect consequences (Mertig et al. 2002: 451ff.). At the end of the 20th century, a third frame finally emerged, which we refer to as the ecology frame. This frame became established alongside the previously dominant environmental protection frame. An ecological perspective, which focuses on the interconnectedness and relationships between different elements, was already included in the environmental protection frame, however this integrative perspective only gradually gained greater significance. Global perspectives are now coming to the fore (e.g., global effects of climate change or the hole in the ozone layer) and the effects of ecological problems in the Global South are increasingly being addressed, with greater attention being paid to issues of justice. The ecology frame's political demands are more explicit and far-reaching than those of the conservation and environmental protection frames: It proclaims that a system and lifestyle change is necessary in order to counter global socio-ecological crises (Mertig et al. 2002: 455ff.).

The different framings of the environmental movement are associated with different strategies and forms of action, whose importance and usage has fluctuated throughout the movement's history and among its different organisations and groups. While conservation groups and organisations mainly used and still use lobbying strategies, the range of different actions grew with the emergence of the environmental protection frame. In addition to lobbying, environmental protection groups and organisations have relied and continue to rely primarily on legal action, petitions and civic engagement. The emergence of the ecology frame brought with it a further differentiation in terms of the forms of action used by the movement. The main focus shifted further towards the practical testing of alternative ways of life (linked to the perceived need for a general change in lifestyle), the election of Green parties and politicians, and direct action (demonstrations, blockades, sabotage, occupations, boycotts, etc.) (Mertig et al. 2002: 452). In particular, organisations and groups that are close to "deep ecology"[26] as an extreme form of the ecology frame (e.g., Animal Liberation Front, Sea Shepherd or Earth First!) resort to confrontational, direct forms of action (Mertig et al. 2002: 473).

Due to the environmental movement's diversity of focal points and its different approaches and instruments, Marco Giugni and Maria Grasso identify heterogeneity as one of the key characteristics of environmental movements (Giugni & Grasso 2015). As the previous sections show, environmental movements are extremely diverse in terms of their dominant frames, objectives, degree of professionalisation and internationalisation, preferred forms of action and organisational constitution. In terms of resource mobilisation, this can be seen as a strength, as it makes it possible to access different types of resources from different sources. With regard to the formation of a uniform collective identity, however, this is a hindrance, as shown by the parallel existence of different frames and their varying consequences for mobilisation and identity formation (Giugni & Grasso 2015: 354f.).

3.3. The structural features of the environmental movement

Alongside the changing frames and backgrounds found in the environmental movement, there are also certain structural features that characterise this movement as a whole. These characteristic structural features include an increasing degree of institutionalisation, a typical social structure and a certain relationship to science.

With regard to the development of social movements, it is generally assumed that, after a dynamic mobilisation phase, they go through a phase of bureaucratisation and institutionalisation, which ultimately leads to ossification and the loss of the movement's character. However, this does not appear to be the case for the environmental movement (Rootes 2004: 633). Despite its institutionalisation and

26 The concept of deep ecology was developed primarily by the Norwegian philosopher Arne Naess and is characterised by a radically biocentric position. This means that nature is ascribed an intrinsic value regardless of its usefulness to humans.

the successes, it has been able to achieve (we will return to this in the next section), it has not lost any of its momentum. The global Fridays for Future movement has been one of the most impressive examples of this. Ultimately, the institutionalisation of the environmental movement can be identified by two characteristics: a) the establishment of concern for the environment in all areas of society, at least on a rhetorical level, and the associated establishment of environmental policy as an independent and important policy field, and b) the emergence of large and established environmental protection organisations and Green parties (Giugni & Grasso 2015: 355). Karl-Werner Brand and Henrik Stöver therefore assumed that institutionalisation does not necessarily have to be associated with bureaucratisation and/or oligarchisation, but that in the case of the environmental movement, a form of institutionalisation has prevailed that is primarily based on the everyday, professional and situational engagement of citizens (Brand & Stöver 2008: 242). In Germany in particular, there was a coexistence of civil society organisations with large memberships and the Green Party on the one hand and confrontational, sometimes even violent protests, particularly in the context of nuclear energy conflicts, on the other (Rootes 2004: 625). However, this coexistence of institutionalisation and protest varies from country to country depending on the political opportunity structures. All in all, when it comes to the environmental movement, institutionalisation does not appear to be an insurmountable barrier to the further mobilisation of protest.

The environmental movement is often described as a social movement that is mainly driven by the so-called "new middle class". This new middle class is made up of people who are highly educated and work in the education or care sector, in the civil service or in the creative industries. Furthermore, this group of people shows post-materialistic rather than materialistic values. The connection between environmental awareness and direct involvement in the environmental movement appears to be less pronounced (Rootes 2004: 617; Giugni & Grasso 2015: 342f.). This can be seen as further evidence that there is no direct causal relationship between environmental awareness and ecological action (→ chap. 4 on environmental attitudes and action). The stronger connection between post-materialist values and involvement in the environmental movement is probably due to the fact that post-materialism is more strongly associated with education than environmental awareness, and that education is also an important influencing factor for the willingness to become involved in civil society and politics (Rootes 2004: 619f.). A relatively high level of education among activists is therefore not an exclusive characteristic of environmental movements, but rather a constitutive feature of many social movements.

Finally, there is a special connection between the environmental movement and the sciences. This close relationship is inherently contradictory, as many environmental problems are only made visible and understandable through science, but at the same time technoscience is also partly responsible for the emergence of many environmental problems (→ chap. 10 on transdisciplinarity). The environmental movement relies heavily on scientific expertise and the interpretation of scientific information in order to make its concerns heard and to justify them, but is also

critical or even mistrustful of technical and scientific progress. As already mentioned, many research institutes emerged from the environmental movement and exemplify the close connection between scientific research and the environmental movement to this day. The Fridays for Future movement, with its demand that politicians should finally take the findings of climate research seriously, is another example of this connection, although it typically ignores the diversity of voices within the sciences. However, both scientific expertise and the lack of scientific evidence are also used by business and politics to justify a wait-and-see, inactive attitude towards certain problems pointed out by the environmental movement. This can lead to a confrontation between expertise and counter-expertise, resulting in a politicisation of scientific findings and their interpretation (Yearley 2005: 19ff.). Nevertheless, scientific knowledge remains one, if not the most important resource of the environmental movement, which it mobilises effectively for its own purposes time and again.

3.4. The social and political impact of the environmental movement

Since social movements are concerned with changing social or political conditions or counteracting impending changes, the question arises from a scientific perspective as to how successful certain social movements were and are as drivers and initiators of social change and learning processes. The environmental movement as a whole is considered to be one of the most influential social movements of all (Rucht & Neidhardt 2020: 850). The environmental movement has succeeded in sensitising politicians and the public to environmental problems and achieving concrete goals (e.g., protection of certain animal species and natural landscapes, restriction of waste disposal on land and at sea, bans on hazardous chemicals) (Rootes 2004: 633; Yearley 2005: 9). At the same time, it is clear that environmental problems, particularly those related to anthropogenic climate change, have continued to worsen in recent decades and that new environmental problems are constantly being added (e.g., the social and ecological consequences of the increased extraction of critical raw materials linked to the spread of renewable energy technologies). It is also obvious that the successes often credited to the environmental movement by various parties cannot simply be causally attributed to the impact of the environmental movement, but that other factors played a role – factors that cannot be fully controlled within the framework of empirical analyses. Accordingly, it is difficult to empirically determine the impact of the environmental movement itself or issue-specific environmental movements in particular (Rootes & Nulman 2015: 729). Christopher Rootes and Eugene Nulman propose different dimensions for determining a movement's impact, namely its influence on a) problem definitions, b) policy formulation, c) policy implementation and d) international agreements.

In terms of socio-cultural problem definitions, the environmental movement can be credited with bringing many ecological problems into the public consciousness. In addition, it has helped to maintain political and public attention on ecological issues even in times of economic or social upheaval (Rootes & Nulman 2015: 734). The environmental movement has also repeatedly been able to influence

the formulation of sector-specific policy goals. In Germany, for example, local protests led to the inclusion of a state clause in the Carbon Capture and Storage Act (KSpG) passed in 2012, which enabled federal states to prohibit CO_2 storage in certain regions (Rost 2015).

As with policy formulation, there are numerous examples relating to policy implementation in which certain political projects have been prevented or politicians have been forced to take action. Environmental activists have successfully blocked the transport of nuclear waste or prevented the construction of nuclear power plants, roads, landfill sites or other environmentally hazardous facilities. They have also repeatedly succeeded in securing the establishment of nature reserves or the protection of endangered animal species. As these examples show, the effects of the environmental movement can be most precisely identified in the area of policy implementation.

In the area of international agreements, environment-related non-governmental organisations in particular have been able to exert their influence. Non-governmental organisations have been formally granted consultative status in the United Nations system, meaning that they can participate in intergovernmental meetings and negotiations and contribute civil society perspectives. This has enabled non-governmental organisations to influence the formation of numerous international conventions on species conservation, whaling, and forestry policy (Rootes & Nulman 2015: 737). In the long term, however, their actual influence seems to be rather small compared to that of other interests and their associated lobbying, as the example of the UN climate conferences repeatedly shows.

4. Outlook

Since the modern environmental movement began in the 1960s, it has not lost any of its mobilising capacity and dynamism. The ongoing exploitation of resources, global networking and scientific and technical innovations are constantly generating new ecological problems and giving rise to conflicts and the emergence of local and supra-regional protests. One current example is the increasing use and spread of hydraulic fracturing (fracking for short), a process that can be used to tap into natural gas and oil wells in previously inaccessible geological formations. Local fracking projects have led to protests by citizens and environmentalists around the world over the past decade. The intensifying anthropogenic climate change, probably the greatest ecological challenge, is also having a strong and growing mobilising effect. Global climate movements such as La Via Campesina, Climate Justice Now! and Fridays for Future are prominent examples of a changing environmental movement that is becoming younger, more involved in justice issues, directly attacking commercial enterprises, organising itself in new ways on social media as well as in camps, and holding its own educational events that are unlike previous formats in order to advance the fight against climate change, species extinction and environmental destruction. At the same time, we are also seeing the rise of a kind of anti-environmental movement that is spreading doubts about climate research and the urgency of taking action. In this mixed situation,

transformation projects such as energy or mobility transitions continue to cause environmental conflicts. Protests against the construction of wind farms or bans on diesel cars are well-known examples. Conflicts over the shaping of society-nature relations and the role that social movements play in this will therefore certainly continue to occupy environmental sociology in the future.

What students can take away from this chapter:

- Knowledge about different types of conflicts and how they are connected
- Knowledge about different theories to explain the success or failure of social movements
- Knowledge about the history of the environmental movement and how its framing of problems has changed over time
- An understanding of what characterises the environmental movement in terms of social structure

Recommended reading

Della Porta, D. & M. Diani, 2020: Social movements. An introduction. *Comprehensive and easy-to-understand introduction to the theory and empiricism of research on social movements.*

Radkau, J., 2014: The age of ecology: A global history. *Comprehensive and detailed account of the history of the environmental movement.*

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Chapter 7: Sustainable consumption

Overview

In this chapter, you will learn about social science approaches to issues of sustainable consumption and the extent to which consumer behaviour is a central component of society-nature relations. You will also learn more about how consumer behaviour is socially structured and why consumption patterns often take on unsustainable forms. It will become clear that consumption is more than the fulfilment of needs and that there are limitations on the extent to which individuals can make free decisions regarding their consumer behaviour and the associated socio-ecological consequences.

Consumption is an integral part of the structure of modern societies and therefore also of everyday life. Accordingly, modern societies are repeatedly referred to as consumer societies (Trentmann 2016), which emphasises the importance of consumptive activities in these societies. The most important characteristic of these consumer societies is the existence of a range of goods that aims to fulfil consumer desires that go far beyond the satisfaction of basic needs, with the result that the majority of the population consumes far more than their basic needs. The rise in real wages and leisure time, the expansion of the credit industry and the widespread implementation of mass production, which reduced the prices of consumer goods, were important drivers of the emergence of consumer societies in the late 19th and 20th centuries, which are characterised by a constantly growing demand for consumer goods (Trentmann 2016). The debate about "sustainable consumption" centres on the question of whether this development can continue. In this context, sociology makes important contributions to a comprehensive understanding of how certain consumption patterns come about and the related consumption of resources and production of emissions. We will outline these contributions below. We will first take a closer look at the concept of (sustainable) consumption, then explain the rational choice perspective, a conceptual approach to consumption that is relevant far beyond sociology. This is followed by a discussion of theoretical perspectives on consumption as a distinctive, symbolic act, and finally we present a practice theories perspective on consumption that has become increasingly prominent over the recent years.

1. What is (sustainable) consumption?

Despite the undisputed great social significance of consumption as a social phenomenon, in general this topic has always been marginalised in sociology as the discipline has tended to focus on the theorisation and empirical analysis of social institutions such as the economy and production, the state and politics, as well as family, education, and culture (Buttel et al. 2002: 20). There is no independent theoretical tradition in sociology focused on consumption (Shove & Warde 2002: 230). Nevertheless, the fact that the way societies and social groups consume has different and sometimes considerable ecological consequences has always been and still is a central part of environmental sociology (Buttel et al. 2002: 19f.). An examination of this topic is essential for a deeper understanding of the relation-

ship between society and nature, not least because of the considerable ecological consequences of consumption.

The term consumption initially appears to require little explanation, as it is also used in everyday language (at least to some extent). In common parlance it usually refers to the purchase and sometimes also to the use of goods and services. In academia the term consumption is often not precisely defined, which results in a somewhat arbitrary use of the term (Evans 2018). The existing attempts to define consumption agree that it is a process that comprises different phases (Campbell 1995b; Warde 2005; Evans 2018). Accordingly, consumption does not consist of a single action, but of a sequence of different actions that take place over time. The starting point of the actual consumption process is the formation of a need or want. This means that the desire for a certain good or service arises among consumers – sometimes deliberately induced by advertising. This emergence of a need is followed by the selection of a corresponding good or service. The focus here is on information-seeking and decision-making activities with regard to the model, design, brand, price, etc., which can be motivated by different needs. When searching for information, however, consumers are usually unable to gain a comprehensive overview of the various product features, as certain characteristics can only be determined on the basis of experience (so-called "experience qualities" such as durability or follow-up costs) or can only be assessed on the basis of expert knowledge (so-called "credence" such as environmental compatibility or the hazardousness of certain ingredients) (Darby & Karni 1973). Once the search for information has been completed with varying degrees of effort and a decision has been made in favour of a particular product, the purchase or procurement phase follows. This phase comprises the various ways in which consumers access the relevant good or service (e.g., buying in a department store, ordering from the internet, borrowing from friends, paying in cash or via credit card, etc.). In the utilisation phase, consumers integrate the relevant good or service into their everyday lives, using and consuming it. The word consumption originates from the Latin verb *consumere* (to consume), which is reflected in the concept of consumption. The final phase of the consumption process is disposal. This phase comprises the various activities involved in disposing of the corresponding good or discontinuing the use of a particular service. With regard to goods, however, this does not necessarily mean that they have to be used up, inedible, damaged, worn out or broken, as a large number of goods are disposed of without this being necessary (Evans 2018).

Figure 9 shows the individual phases of the consumption process in chronological order.

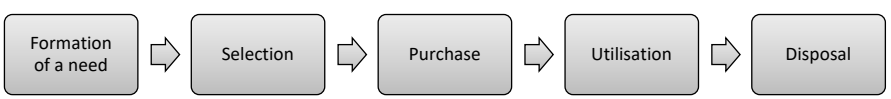

Figure 9: Phases of the consumption process; source: own illustration

It is obvious that the type of goods and services that people consume, as well as the way in which they are consumed and disposed of, have socio-ecological consequences. However, an understanding of the (unintended) consequences of consumption has been slow to emerge. Although the term sustainability – or more precisely the verb "to sustain" – was coined by Hans Carl von Carlowitz in his book on forestry "Sylvicultura oeconomica" as early as 1713 (Grober 2012), it would take over two hundred years for the scientific community and, as a result, the public to take up the term again. In 1972, a study entitled "The Limits to Growth" was published by the Club of Rome, an international association of scientists from a wide range of disciplines. In this study, the authors drew an extremely bleak picture of the future of the Earth based on computer simulations that revealed what would happen if humanity did not begin to live and do business more sustainably. The study attracted a great deal of attention worldwide, not least because of its gloomy forecast for the future. The report "Our Common Future" by the World Commission on Environment and Development, which was set up by the United Nations in 1983, was particularly influential for the political understanding of the concept of sustainability. The report is also known as the Brundtland Report, because at that time the commission was chaired by then Norwegian Prime Minister Gro Harlem Brundtland. It defined the concept of sustainable development as follows: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations 1987: 41). This definition refers to the necessity of fulfilling (intergenerational) needs, which connects sustainable development to the topic of consumption as a means of satisfying needs. At the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, sustainable development was established as a normative guiding principle of the international community. As a result, political decision-makers became increasingly aware of the need to reorient consumption towards sustainability and this thinking gradually found its way into political and public debates (for a detailed history of the concept of sustainability and the development of the term, see Grober 2012). Current debates about food waste, microplastics in the oceans, fair trade and the degree to which private households contribute to global CO_2 and polluting emissions are just some examples of the many ways in which the socio-ecological consequences of consumption in modern societies are publicly problematised. Based on the Brundtland Report's definition of sustainability, sustainable consumption can be defined as a form of consumption in which goods are acquired, used and disposed of in such a fashion that all humans, now and in the future, are able to satisfy their (basic) needs and that their desire for a good life can be fulfilled (Defila et al. 2012). It should be emphasised here that the socio-ecological effects of certain consumption activities do not necessarily have to correspond with individual intentions. In other words, individual consumption behaviour may well prove to be sustainable, even though this was not explicitly intended. Conversely, however, explicitly ecological intentions often also lead to negative socio-ecological consequences. For example, Stephanie Moser and Silke Kleinhückelkotten show in an empirical study that particularly environmentally conscious people actually have a larger carbon footprint than less environmentally

conscious people (Moser & Kleinhückelkotten 2018). This is mainly due to the fact that environmental awareness correlates positively with education, which in turn correlates positively with income. A higher income opens up more consumption opportunities, which usually has negative environmental consequences. This means that the potentially positive effect of people's intentions to act in an environmentally friendly way is counteracted by a negative effect caused by their income. Therefore, when analysing sustainable consumption, a distinction must be made between an impact-based and an intention-based perspective (Stern 2000). From an impact-based perspective, the investigation of the socio-ecological consequences of consumption patterns takes centre stage, while from an intention-based perspective, the focus of the investigation is on the social, cultural and psychological drivers of consumer behaviour. The combination of both perspectives then results in a comprehensive picture of consumer behaviour and its effects, which are influenced by conscious and unconscious mental dispositions (preferences, values, attitudes, etc.) and mediated by social and socio-technical structures (social situation, infrastructures, policies, institutions, etc.).

If we want to take a more differentiated look at consumer behaviour, we can first make a rough distinction between inconspicuous, everyday and non-everyday consumption. Although this distinction is not completely free of overlaps, it is nevertheless helpful for better understanding the drivers of certain consumer behaviour. The term inconspicuous consumption describes the largely unconscious and unnoticed consumption of resources in connection with certain actions (e.g., water consumption when showering). Everyday consumption refers to repetitive acts of consumption that are firmly anchored in everyday life (e.g., buying butter, watching TV or streaming a series). Finally, the term non-everyday consumption refers to more or less unusual acts of consumption that are not determined by routines (e.g., buying a car or house) (Gronow & Warde 2001; Evans 2018). As already mentioned, some acts of consumption are highly routinised and performed without major cognitive effort, while other acts of consumption involve a high degree of mental involvement. Accordingly, a further distinction can be made between high-involvement and low-involvement products and activities. High-involvement products and activities are characterised by the fact that they are strongly "charged" with personal and social meaning and therefore have greater significance for the definition of oneself (Belk 1995). For example, for most people, a car plays a greater role in the expression of their identity than the towels they own. However, the degree of involvement also depends on situational and individual factors such as personality traits, state of mind, disposable income or previous experiences and can change throughout the phases of the consumption process described above. Similarly, a consumer good and the associated consumption actions may move between the three categories of consumption (inconspicuous, everyday, non-everyday) during the consumption process. For example, the purchase of an electric car is a non-everyday act of consumption, while its use is categorised as everyday consumption and the energy consumption associated with its use is categorised as inconspicuous consumption. In terms of the purchase, an electric car can certainly be described as a high-involvement product, while its use is more likely to be a low-involvement activity characterised

by routines. There are also moments when routinised consumption activities are interrupted, reconsidered and reorganised, such as food consumption after the birth of children or mobility habits after moving house. These triggers for biographically induced reflection and greater involvement in consumption behaviour and decisions are regarded as windows of opportunity in which more sustainable consumption options can be communicated and established (see, for example, Prillwitz et al. 2006; Schäfer et al. 2012).

2. People as rational decision-makers

In environmental policy, there is a prevailing assumption that environmentally friendly behaviour can be influenced by financial incentives. Explanations provided for (non-)sustainable consumption are thereby based on an idea of people as rational decision-makers. Human action is explained in terms of individual cost-benefit calculations, based on the assumption that people make decisions within the limitations of their personal context (available time, available money, perceived options for action, etc.) that they hope will deliver the greatest benefit. This means that people choose the option that promises them the greatest benefit or utility from a range of different options (Liebe & Preisendörfer 2010). Accordingly, environmentally friendly behaviour is not primarily based on environmental awareness but on rational cost-benefit calculations. In sociological variants of rational choice theory, utility is not necessarily defined purely in economic terms, but can also refer to saving time, increasing social recognition, securing one's social identity, etc. This is linked to an emphasis on the subjective perception and definition of what is considered a benefit. In sociological models of rational choice, benefits (and the corresponding probabilities of their occurrence) are therefore usually defined as subjectively perceived or expected utility (Liebe & Preisendörfer 2010). Furthermore, the rule of utility maximisation is partially limited as it is replaced it with the less strict rule of "satisficing" (Simon 1955). The assumption of complete rationality is relaxed in favour of the assumption of bounded rationality (Simon 1979). In other words, in complex decision-making situations people behave with only bounded rationality due to cognitive overload: The complexity of the situation exceeds the mental capabilities of the decision-makers to select the option that actually promises the greatest benefit. In addition, people have a certain level of expectation that regulates their additional search for information and thus the effort required to arrive at a decision that will maximise the benefits. Accordingly, when making decisions, people are often satisfied by choosing an option that is perceived as satisfactory without wanting to find the most beneficial option under any circumstances.

Following on from rational choice theory, Andreas Diekmann and Peter Preisendörfer introduced the low-cost hypothesis as an answer to the question of why environmental awareness is often not reflected in corresponding ecological behaviour (Diekmann & Preisendörfer 2003). According to the low-cost hypothesis, environmental awareness only translates into environmentally friendly behaviour if it is a low-cost situation. A low-cost situation exists when the costs of the less environmentally friendly alternative minus the costs of the environmen-

tally friendly alternative are negative, but close to zero, for as many people as possible (Diekmann & Preisendörfer 2003). Accordingly, environmentally friendly behaviour is usually only evident when it entails low costs in terms of money, time, effort or convenience. This may explain why people are more inclined to buy organic food and separate their waste than to do without a car or even just drive less. In perceived high-cost situations, such as not owning a car, subjective cost-benefit calculations such as the expected loss of comfort and flexibility, which in this case represent barriers to action, are more decisive than a person's environmental awareness. This leads to the conclusion that it is not appeals to environmental awareness or measures to increase environmental awareness that are decisive, but rather the reduction of barriers to action and costs in situations perceived as high cost.

The concept of people as decision-makers who are rational (albeit to a limited extent) and seek to maximise their own benefit has been criticised many times (Shove 2010). One of the main objections is that environmentally friendly behaviour cannot be fully understood as a rational choice, as behaviour is also shaped by lifestyles, worldviews, emotions, routines, cultural traditions, needs for distinction, embedding in socio-technical systems and household arrangements, etc. In addition, an empirical argument made against the low-cost hypothesis is that whether or not a person's attitude is translated into action depends on the strength of their attitude. Accordingly, environmentally friendly attitudes can also guide action in high-cost situations if they are so strong that they override cost-benefit calculations. The low-cost hypothesis would therefore be better described as a low-attitude hypothesis (Best & Kneip 2011).

All in all, rational choice theories have always proven useful in environmental research when it comes to analysing clearly defined decision-making situations with transparent cost structures. In contrast to this, the next section focuses on the symbolic dimension of consumption.

3. The symbolic dimension of consumption

Self-presentation and people's need for distinction are important when it comes to consumer behaviour. This is demonstrated in discussions about the symbolic functions fulfilled by consumer goods. Although the fulfilment of these functions can also be interpreted in part as generating utility for the individual, the symbolic functions of consumption go far beyond the assumption that people base their consumption behaviour on rational cost-benefit calculations. Instead, the underlying theories emphasise the socio-cultural shaping of individual actions and the embedding of those actions in contexts of social interaction and therefore do not focus on individual people as decision-makers. Consumer goods fulfil symbolic functions that are socially constructed and therefore not inherent to the goods, but rather have a socio-structural character (Goffman 1951). The symbolic value of goods is attributed to the goods in the context of social interaction processes and is based on a shared horizon of meaning (Slater 2008). This shared horizon of meaning enables people to deduce what symbolic value a consumer good has

for others on the basis of what value it has for them. Similarly, they can use this knowledge to predict what reactions a particular consumer good will most likely trigger in others (Mead 1972 [1934]: 117ff.).

In order for consumer goods to fulfil a symbolic function at all, they must meet two requirements: significance and visibility (Wiswede 2000). Significance describes the collectively shared attribution of meaning (Wiswede 2000: 40). This means that the symbolic meaning of a certain consumer good must be recognised and understood as such by other people. If, for example, the social milieu of a solar system owner does not recognise and understand solar systems as sustainable products, the solar system cannot function as a symbol of sustainability in that milieu. The concept of visibility refers to the visibility of the symbolically charged consumer good. If the good is not visible to others, its symbolic value does not materialise.

The symbolic dimension of consumer goods is related to three central consumption functions (see, for example, Campbell 1995b: 111). These are presented and described in more detail below:

a) Positioning function: The significance of consumer goods for the visualisation and display of social positions and social status was most prominently and elaborately explored by Pierre Bourdieu (Bourdieu 1984) and Thorstein Veblen (Veblen 2007 [1899]). According to their findings, one of the functions performed by consumer goods is the drawing of boundaries between different people, social groups or classes. Consumer goods make statements about a person's social position and thus about their status in society. In this context, Thorstein Veblen coined the term "conspicuous consumption", which describes how people use consumer goods to visualise, assert or even enhance their social position in relation to others (Campbell 1995a: 38). The most obvious example of this is probably the significance of certain cars as status symbols – the owners of such cars sometimes try to use them to express their wealth and success for all to see. While Thorstein Veblen's concept of conspicuous consumption referred to more obvious, direct forms of status representation through consumer goods, Pierre Bourdieu worked out in detail the more subtle, indirect forms of social distinction by showing how consumption practices that are not immediately visible also serve to draw social boundaries. Going to the opera, for example, is not only a means of personal enjoyment, but also a method of symbolic demarcation from other social groups that are not associated with "high culture", and ultimately a subtle expression of one's own categorisation as a person with refined taste that is perceived as superior.

b) Integrative function: Consumer goods not only serve as symbols of demarcation, but also fulfil an integrative function by marking group affiliations and thus materialising and stabilising social orders. In their book "The World of Goods", Mary Douglas and Baron Isherwood present a cultural and anthropological interpretation of modern consumer societies (Douglas & Isherwood 1996 [1979]). They oppose the interpretation that consumption primarily serves to demonstrate status and emphasise that consumer goods represent a means of integrating com-

munities: "Within the available time and space the individual uses consumption to say something about himself, his family, his locality, whether in town or country, on vacation or at home. The kind of statements he makes are about the kind of universe he is in, affirmatory or defiant, perhaps competitive, but not necessarily so" (Douglas & Isherwood 1996 [1979]: 45). Thus, in many societies and social groups the excessive consumption of meat symbolises masculinity, which in turn manifests and reproduces the gender relations in a given social order. In the same way, consumer practices such as dinner parties serve to embed people in group contexts and strengthen social relationships. Consumer goods and consumer behaviour thus become a cultural categorisation and information system within the social order and therefore reflect the society in which people want to live, which social order they prefer and which they oppose (Sassatelli 2007: 49).

c) Expressive function: Although the expressive function of consumer goods overlaps with the two functions described above, it can certainly also be distinguished from them. While the other two symbolic consumption functions focus on the manifestation, stabilisation and reproduction of social relationships and thus social order, the expressive function is aimed at the expression and construction of identity. Identity can be understood as the sum of all historically developed personal and social characteristics, in which the image one has of oneself is reflected and which one presents to others (Friese 1998: 40). Herbert Marcuse and Erich Fromm summarise – with critical intent – the connection between identity and consumption in modern societies as follows: "The people recognize themselves in their commodities; they find their soul in their automobile, hi-fi set, split-level home, kitchen equipment. The very mechanism which ties the individual to his society has changed, and social control is anchored in the new needs which it has produced" (Marcuse 1992 [1964]: 11) or "I am = what I have and what I consume" (Fromm 2008 [1978]: 27). Zygmunt Bauman in particular has meticulously elaborated on the precise fit between consumer culture and the specific conditions of modernity and emphasises that, under modern conditions, identities are no longer fixed into a certain social position at birth, but must be painstakingly constructed, constantly adapted and maintained (Bauman 2007). Identities thus become projects. For many people, consumer goods such as clothing or furniture play an important role in the successful realisation of these projects. Paradoxically, however, people in modern societies, who are forced by the dynamics of those societies to construct their own identity and present it to the outside world, find themselves confronted with a largely standardised product range thanks to the prevalence of mass production. Andreas Reckwitz also takes up this point in his investigation of the extent to which digital products (profile pictures, playlists, etc.) and services contribute to the "specialness" of individuals and support their strategies for stylising "singularity" (Reckwitz 2020).

Of course, many consumer goods fulfil different symbolic consumption functions at the same time. For example, the purchase of organic food can serve both to distinguish oneself from other social groups perceived as less environmentally aware and health-conscious (positioning function), to show oneself as part of a community of "conscious" people and consumers (integrative function) and

to assert one's own identity as an environmentally aware and health-conscious person (expressive function). Most consumer goods also have both symbolic and practical value, albeit to varying degrees. For example, cars are characterised by high symbolic value and also high practical value, while cooking pots have a high practical value but hardly any symbolic value. Ultimately, the value attributed to a good is not based solely on its practical value, but is also derived from its symbolic value. In modern societies, which are characterised by largely saturated markets offering a wide range of products, symbolic value is even becoming more and more important, as consumers can choose from a variety of products that are similar in terms of their practical value (Hirschman 1981: 4). The symbolic value thus becomes a decisive factor for the sale of a consumer good. A current example of this is the growing prevalence of food labelled as "organic". Regardless of how organic their production method actually was, these days such foods promise a symbolic added value compared to other conventionally produced foods. This example also shows how the symbolic value of a consumer good can change due to socio-cultural change: In the 1980s and 1990s organic food was quite uncommon, partly due to its rather negative reputation. Many people regarded organic food as unhygienic and those who consumed it as organic fanatics. Organic food only became attractive to broader consumer segments once health consciousness and environmental awareness began to grow among the population.

4. Practices of everyday consumption

While the theories of rational choice introduced above focus on the individual and their conscious decisions, theories of practice focus on analysing how everyday life is carried out within the framework of social practices. The units of analysis are no longer individuals, but practices such as cooking, shopping, showering, driving, etc. (Reckwitz 2002). There are a variety of definitions for the concept of practice and different views about the elements that ultimately make up a practice (see, for example, Schatzki 1996; Reckwitz 2002; Shove et al. 2012). Generally speaking, practices are "embodied, materially mediated arrays of human activity centrally organized around shared practical understanding" (Schatzki 2001: 2). In other words, these are human activities that are physically mediated through the use of material objects, draw on a practical consciousness and are largely routinised (Reckwitz 2003: 284). The concept of practical consciousness describes "all the things which actors know tacitly about how to 'go on' in the context of social life without being able to give them direct discursive expression" (Giddens 1984: xxiii). Thus, the practice of driving is a physical activity (shifting gears, steering, etc.) for which material objects such as the car itself or roads as infrastructure are necessary and which takes place largely unconsciously by drawing on internalised skills (how to follow road traffic regulations, knowledge of the meaning of traffic signs, etc.). The use of the car for regular journeys, e.g., driving to work or to do the weekly shopping, usually follows routines that are only questioned in crisis situations.

The term "practice theories" is deliberately used here in the plural, as there is no single generally recognised practice theory as such, but rather different approach-

es and theories that exist in parallel, all of which focus on the examination of practices (Reckwitz 2002). Anthony Giddens' structuration theory (Giddens 1979, 1984, 1993) and Pierre Bourdieu's habitus concept (Bourdieu 1977, 1984, 1990) are classics in this field. More recently, the practice theories proposed by Elizabeth Shove (Shove 2003; Shove et al. 2012) and Theodore Schatzki (Schatzki 1996; Schatzki 2010) have gained widespread attention in the field of sustainable consumption research. Elizabeth Shove and her colleagues have made specific efforts to analyse issues in the field of sustainable consumption from a practice theory perspective, so their approach will be discussed in more detail below.

Elizabeth Shove and her colleagues assume that practices are made up of competencies, meanings and materialities. The term competence describes the practical knowledge and skills required to carry out a practice. Meaning refers to the shared social understandings associated with the performance of a practice, and material objects refer to the objects, devices, products and biophysical elements (e.g., water, fuel, electricity, etc.) whose use is involved in the performance of a practice (Shove et al. 2012: 22ff.). Furthermore, practices are not isolated units, but usually occur as bundles. This means that practices are linked to each other via their individual elements or sequential order (Shove et al. 2012: 105ff.). For instance, the practices of washing clothes and showering refer to the same meaning of cleanliness and the associated social norms of cleanliness. An example of the sequential linking of practices is the practice of shopping, which is followed by the later practice of cooking. In addition, to carry out practices larger infrastructures are usually required so that the material objects involved can function at all (Shove et al. 2015; Shove 2016). The functionality of bicycles or cars, for example, depends on the existence of a corresponding road infrastructure and also varies with the nature of this infrastructure; electrical devices require electricity, which is generated in power plants and distributed via power grids and power lines.

According to Elizabeth Shove and colleagues, practices change as one or more of their elements (competencies, meanings and materialities) change (Shove et al. 2012). For example, the practice of cooking has changed significantly over the decades due to the spread of the freezer as a material object (Shove & Southerton 2000; Hand & Shove 2007). Freezers contributed to the spread of convenience food, which requires far fewer practical skills to prepare than conventionally cooked food. Food preparation also became less time-consuming and easier to plan, making the freezer a time-saving factor. Parallel to the spread of freezers in households, a new infrastructure for the provision of frozen food also emerged: Refrigerated warehouses, freezers in supermarkets, new forms of food production, etc. became necessary and widespread. Compared to the conventional system of food provision and preparation, however, this entails far greater energy consumption and thus has corresponding ecological consequences.

Another example is the increasing prevalence of air conditioning, which is changing work practices, among other things. In air-conditioned rooms, there is no need to take off one's jacket and tie in hot weather, which ultimately goes hand in hand with a change in the meaning of appropriate clothing in the workplace (Walker

et al. 2014). In this way, certain clothing norms are standardised and stabilised, which in turn makes air conditioning a necessity. This also highlights the interaction between practices, the necessary infrastructures and the corresponding social contexts of meaning.

The strength of a practice theories perspective lies in focusing on how practices emerge over time and change through interactions with other practices, infrastructures, and production and provision systems. Unlike theories of rational choice, the focus is not on the individual as a rational decision-maker, but rather on the socio-material embedding of human activities. With regard to making consumption patterns more sustainable, a theory of practice perspective suggests intervening in the interactions between everyday life, infrastructures, and institutions (Spurling & McMeekin 2016; Cass et al. 2018). This means that the way to reduce car use, for example, would not initially be – as rational choice theories would suggest – interventions in the cost structure of car use (e.g., increasing petrol prices), but a more comprehensive approach aimed at changing infrastructures and legal regulations (→ chap. 9 on infrastructure systems). From a theory of practice perspective, one would ask: To what extent does the way our cities are designed (e.g., policies to ensure car-friendly cities) tend to enable certain practices while complicating and preventing others? It would also be necessary to analyse which social norms, standards and legal regulations stabilise and reproduce unsustainable practices and bundles of practices.

5. Outlook

Apart from the research fields and theoretical approaches described above, there are also a number of other research questions currently being investigated in the corresponding sociological research. In conclusion, we will therefore outline three (primarily empirical) further research topics: the social structuredness of sustainable consumption, "prosuming" and sharing.

In the 1990s and early 2000s there was widespread euphoria that conscious and sustainable consumption could become the driving force behind sustainable development in Western societies. Since then, this sense of euphoria has clearly diminished. The idea of sovereign consumers who are increasingly aware of the negative socio-ecological consequences of their actions and adapt their consumption behaviour accordingly, and the associated research on the motives that drive sustainable consumption, has increasingly given way to a perspective that focuses on the social structuredness of sustainable consumption (→ chap. 4 on environmental attitudes and action). This means that the socio-structural conditions of consumer behaviour, such as class affiliation or socio-economic disadvantage, are receiving more attention. As a result, traditional sociological topics are increasingly becoming the focus of empirical research on sustainable consumption. Examples include the topics of energy poverty as a form of social inequality (Guevara et al. 2023) and sustainable consumption as a strategy for distinguishing oneself socially (Neckel 2018).

The term "prosuming" was coined in the early 1980s by futurist Alvin Toffler (Toffler 1981). He used it to describe a form of consumption in which the roles of consumer and producer overlap. This means that consumers produce the products they consume (at least in part) themselves. For example, the development of solar systems and their spread in private households has led to more and more citizens consuming self-generated energy and thus taking on the role of prosumers in the energy system (Brown et al. 2020). Examining the conditions and implications of this change, which is currently also evident in other sustainability-related areas such as urban gardening and repair cafés (Jaeger-Erben et al. 2021), is another relevant research topic.

For a short time, internet-based sharing platforms and services – such as Uber, Airbnb and various car-sharing services – were discussed by academics and the general public as a way to make consumption more efficient and therefore more environmentally friendly through the sharing of goods and products (e.g., tools, cars, apartments, etc.). In the meantime, however, the dark sides of so-called platform capitalism (Srnicek 2017) have come to light, which manifest themselves in exploitative labour conditions and the growing energy consumption of server farms, among other things. An examination of the conditions and socio-ecological advantages and disadvantages of the (digitally mediated) communal use of resources based on temporally limited sharing is therefore another relevant field of research that will become increasingly important in the future (Frenken & Schor 2017).

What students can take away from this chapter:

- Knowledge about what is meant by consumption
- Knowledge about the connection between attitudes and consumer behaviour
- Knowledge about the different social functions of consumption
- An understanding of the practice theories perspective on everyday consumption

Recommended reading

Diekmann, A. & P. Preisendörfer, 2003: Green and greenback. The behavioral effects of environmental attitudes in low-cost and high-cost situations. *Basic empirical application of rational choice theory in the field of sociological research on environmental behaviour and corresponding critical appraisal.*

Douglas, M.T. & B. Isherwood, 1996 [1979]: The world of goods. Towards an anthropology of consumption. *A classic but sometimes difficult to read book that analyses the cultural foundations of consumer behaviour and includes a corresponding critique of economic perspectives.*

Evans, D.M., 2018: What is consumption, where has it been going, and does it still matter? *Compact overview of the current state of sociological consumption research.*

Trentmann, F., 2016: Empire of things. How we became a world of consumers, from the fifteenth century to the twenty-first. *Comprehensive overview of the conditions and history of the development of consumer society.*

Shove, E., M. Pantzar & M. Watson, 2012: The dynamics of social practice. Everyday life and how it changes. *Fundamental, systematic presentation and application of a theory of practice perspective to questions in the field of sociological environmental research.*

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Chapter 8: Sustainable innovations and transformation processes

Overview

In this chapter, you will become familiar with the requirements, difficulties and diffusion of sustainable innovations and their contribution towards a sustainable society. You will learn about the goals of sustainable development and innovation processes from a sociological perspective with a focus on how they emerge within networks and how they are implemented in everyday life. We will also present and discuss the multi-level perspective (MLP), a multi-level theory of sustainability oriented transitions.

Around the world, typical lifestyles and economic practices are too resource-intensive, too environmentally damaging and too unsustainable in socio-ecological terms to be continued without causing any problems. For this reason, modern societies are increasingly faced with the immense task of fundamentally changing their unsustainable practices and developing new ways to satisfy people's needs in all areas of activity. *Sustainable innovations* promise to fulfil the ecological, social and economic aspects of politically defined sustainability goals by means of new products, processes and arrangements. Beyond selective innovations to improve the ecological balance, the aim is to fundamentally reverse the current trends of using up finite resources, eradicating species, producing hazardous emissions and waste and thereby driving global climate and environmental change that jeopardises human life on planet Earth and could even wipe it out completely. Lifestyles and economic activity that do not pose a threat to the climate, environment or health, but will instead leave behind a habitable world for future generations, are considered future-proof, sustainable or "fit for grandchildren".

1. The guiding principle of sustainable development

The concept of *sustainable development* and its various dimensions, indicators and conflicts have been the subject of many studies in science and politics since the report "*Our Common Future*" (1987) was published by the World Commission on Environment and Development, which was set up by the United Nations in 1983. The report described development as sustainable if the needs of the present are met without risking the ability of future generations to meet their needs[27]. The commission, chaired by the Norwegian Gro Harlem Brundtland, therefore focused on the existential needs of all people worldwide and future generations and sought to harmonise economic development with the imperatives of sustainability. It focused on inter- and intra-generational justice in relation to the management of finite resources and the limited resilience of ecosystems and subsequently led to regional "agenda processes" worldwide that were designed to specify how the regulatory idea of sustainable development could be implemented

27 The concept of sustainability originally comes from forestry and was introduced by Hans Carl von Carlowitz three hundred years ago to ensure that the amount of wood taken from the forests did not exceed what could be regrown for mining and construction purposes. The term therefore focused on the use of resources and their natural regenerative capacity, with the aim of being able to meet future needs.

in an economically, ecologically and socially compatible way (→ chap. 7 on sustainable consumption).

To this day, the main obstacle on this path is the lack of consensus on how sustainability can be achieved, what a "good life" is, which "needs" have to be met to achieve it and how an ecologically "just fulfilment of needs" can also function socially and economically. In this respect, opinions differ not only in international comparisons, between North and South, East and West, but also between the social groups and milieus of individual countries. After much debate, the United Nations once again agreed on a series of ambitious political principles in the form of the seventeen *Sustainable Development Goals (SDGs)* that came into force in 2016. The goals have a stronger focus on simultaneously overcoming poverty and inequality, enforcing human rights and creating equal opportunities and resilience through international cooperation on the path to sustainable development. However, like the "Our Common Future" report, the SDGs contain many compromises and assume a consensus on common goals that does not exist and which is also thwarted by conflicting goals. In addition, the goals can be pursued in different ways and are partly dependent on factors that are beyond the scope of national and international strategies. For example, armed conflicts, forest fires and, in particular, the growth of the world's population thwart existing approaches. In view of these difficulties, innovations promise sustainable social change by taking a creative approach to the challenges of sustainable development and the establishment of new ways of satisfying needs. Innovations are usually sought primarily in the context of new technologies – less often in "social" contexts or in relation to fundamental systemic change (socio-ecological transformation).

Within environmental sociology is some doubt as to whether innovation and a primarily technology-driven search for new opportunities is the best way to achieve sustainable development, as this focus is often associated with growth and competition-oriented ideas about development and less with values such as solidarity, frugality or even the renunciation of certain goods and services, all of which appear necessary for global sustainability as per the sufficiency principle and in light of the planet's limited resources (Jungell-Michelsson & Heikkurinen 2022). The implementation of "innovative" forms of problem solving that are associated with fewer resources and emissions and are referred to as "sustainable innovations" is therefore only promising if it is accompanied by a corresponding change in awareness, and if these innovations actually help us to move beyond resource-intensive lifestyles instead of prolonging them or enriching them with additional unsustainable options (*e.g., buying an electric car as the family's third car*).

2. Sustainable innovations

Unlike the concepts of sustainable or socio-ecological transformation (WBGU, 2011), talk of sustainable innovations often only refers to *technical* innovations without a simultaneous change in guiding principles. From this perspective, sustainable innovations promise the maintenance of today's lifestyle – and even

growing prosperity – while at the same time decoupling these goals from resource consumption. In the past, innovative technologies have often been able to improve resource efficiency and minimise harmful waste. However, the sustainability gains did not lead to a trend reversal, but were in many cases overcompensated by so-called rebound effects, for example when the introduction of more fuel-efficient cars led to more journeys as a result of the lower mobility costs and because drivers felt that the increased fuel-efficiency gave them a moral license to use their cars more (Sonnberger & Gross 2018). The rebound problem becomes most obvious when we look at global energy consumption, which is continuously increasing and for which coal – a particularly climate-damaging fossil fuel – continues to supply the lion's share. For this reason, many critics of growth view the hope that environmental consumption can be decoupled from growth ("*green growth*") as unrealistic and are instead thinking about post-growth societies with completely changed forms of economic activity and welfare production (Latouche 2006). They are therefore focusing more on *social* innovations and social reforms, including *exnovation* as a form of renewal through which unsustainable products, processes and thought patterns are eliminated without replacement.

In the following, we will use the term *sustainable innovations* to refer to such development and change processes to be sustainable innovations which facilitate, use and diffuse novel technical, organisational, practical, institutional and cultural solutions with the goal of facilitating lifestyle and business models that are transferable globally and in the long term, and contributing to social structures that promote health and fairness and protect the environment. They can only curb resource consumption harmful to humans and the environment and prevent dangerous emissions if they take effect on a "targeted basis" from the idea stage for sustainable options to the implementation and diffusion phase so that their use leads to sustainable routines that improve sustainability footprints as a result and they make an exnovative contribution to curbing unsustainable lifestyles and business models (Kropp 2018: 7).

In contrast to the everyday understanding of the term, "innovation" does not (only) refer to ideas or inventions, but also to their implementation as "new combinations" (Schumpeter 2021 [1911]: 62ff.), which *prevail* in the respective areas of activity and markets. Innovations or innovation processes are therefore more than just ideas – they change, supplement or replace what already exists. A good idea for sustainable solutions that is not taken up by anyone is irrelevant, both environmentally and in terms of innovation theory. The difference between an idea and an innovation lies in the realisation and diffusion of "the new", which sustainability innovations unfortunately fail to achieve in the majority of cases. They often remain unused or abide in ecological milieus and niches (e.g., grey water toilets or passive houses) (Fichter & Clausen 2016; Kropp 2023). Since the beginning of innovation research with the work of Schumpeter (2021 [1911]), the term innovation has therefore referred to a process that ranges from invention and testing (prototypes) to the introduction and implementation of innovations, and is influenced by many imponderables. The terms *invention*, *incubation*, *introduction* and *diffusion* are often used to describe the ideal type of innovative

process, which usually includes detours, setbacks and aberrations in terms of subject matter, time and location.

In the following, we examine three main directions of innovation research. They differ primarily in terms of the influencing factors they pay particular attention to, but also with regard to their assumptions about the malleability of innovation processes. What they have in common is that they reject reductionist and linear ideas that claim the realisation of innovations is a question of "better" ideas, technologies or strategies. Instead, sociological innovation theories focus on innovation networks and the different levels of innovation, and take into account the diversity and interconnectedness of technical, socio-cultural and economic influences in innovation processes.

3. Theories about the routinisation of innovation

Gabriel Tarde, a contemporary of Emile Durkheim (2012, first published in 1890), was one of the first to study the diffusion and routinisation of inventions and discoveries: In his view, social development is imitation. Tarde reflected on social change in the interplay between processes of contingent *inventions/innovations* and their *imitation*. According to his theory, innovations that arise in all areas of society are actively taken up and diffused, either partially or comprehensively, by individual agents of a group through acts of imitation in "imitation chains". For this to happen, however, the innovations must be compatible with existing values and structures, on which they in turn have an effect, making further inventions possible or impossible. What is special about this early sociological perspective is that Tarde's approach contains relational elements, i.e., it mediates between sociological theories of action at the individual level and macrosociological theories of structure: For him, social facts gain greater profiles as they are spread through individual imitation. Social facts are therefore not a necessary precursor for the explanation of social phenomena, as in the work of Durkheim, but are seen by Tarde as a temporary result of the routinisation of imitated practices. According to Tarde, this imitation spreads from an interior of high complexity and creativity, in which the new creation originated, to an exterior of stronger standardisation and imitative repetition. First the perceptions and interactions of individual imitators change, then the innovations manifest themselves in a more standardised way at the level of practices and institutions. For Tarde, this standardisation or "routinisation" at the level of customs, language, behaviours and economic forms enables the social linking of more or less voluntary acts of imitation, as well as their further differentiation in the area of tension between learning adaptation and modifying opposition. In his innovation-oriented view, the development of society is therefore always the provisional and fragile result of imitation processes through which inventions are stabilised, modified or discarded.

Tarde would probably not have been surprised that sustainability innovations such as car-sharing, grey water toilets, vegan diet or attempts to create a circular economy are not copied in the way they were envisioned, but instead interact

with the simultaneous spread of unsustainable innovations and lose their sense of direction, are modified, dumped or become the subjects of incomplete imitation and end up having unsustainable consequences. Therefore, for environmental sociologists the fundamental question about sustainable innovations is: What conditions are required for the routinisation of sustainable innovations so that they can make a substantial contribution towards the creation of a sustainable society?

From the point of view of diffusion research and in particular its best-known representative, Everett M. Rogers, communication processes play a decisive role here. Through communication processes, information about the innovative novelty is diffused in social communication channels and networks and then successively adapted by other social groups or spread as positive deviations via their networks (Rogers 2003, first in 1962; Rogers et al. 2009). Diffusion research is particularly interested in the time required for this to take place and how amenable different social groups are towards innovation, as these factors make it possible to estimate the required diffusion effort.

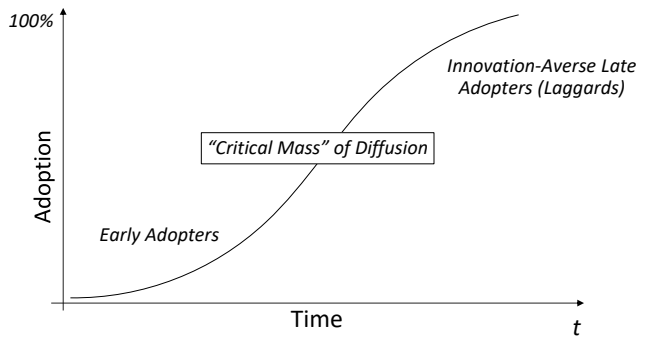

Figure 10: Diffusion process, depicted as an S-curve according to Rogers; source: own illustration based on Rogers et al. (2009: 427)

The faster an innovation is adopted and establishes itself, the faster it reaches the "critical mass" and leads to financial gains for entrepreneurs, prestige for pioneers and the need for later imitators (*adopters*) to follow suit. This process leads to a routinisation of the innovation in the respective area of activity until it is no longer perceived as an innovation at all. Empirical studies on diffusion processes have often shown that younger, more highly educated people and men are more open to innovations than less qualified people and women, who usually adopt innovations later. Even back in Tarde's days, inventions tended to be made by a small number of prestigious players, while repetitive (but also creative) adoption took place among the broad majority. Sustainable innovations are also more likely to be adopted by younger and better educated people, although women are statistically more orientated towards sustainability than men. Overall, however, all externally induced changes that represent a deviation from the familiar and a break with routine are initially met with little approval by those affected, even though modern societies supposedly have a strong orientation towards innova-

tion. In contrast, a number of inertia forces mean that incremental innovations, which only require minor changes to existing routines and skills, have a better chance of being implemented than radical innovations. In addition, innovations are adopted and changed in a context-specific manner throughout the course of diffusion, as Tarde already pointed out.

Sociologically, the delayed and stubborn adoption of innovations can be explained by the fact that they – like social deviation in general – dissolve the predictability that previously facilitated social behaviour and provided orientation. Innovations cause uncertainty and require organisational and socio-technical adaptation measures to overcome the fact that they do not fit with the old and familiar. In this respect, all innovations require the development of new competencies and devalue existing experiences and skills. Innovation and transformation processes are therefore rarely met with spontaneous acceptance, but are instead fended off at various levels of society or only adopted gradually or after some form of adaptation. This situation gives rise to the aforementioned supposed paradox that the innovations that diffuse most successfully are those that deviate the least from the status quo or whose level of innovation is characterised as low. Their incremental novelty is easier to integrate into existing everyday practices and behavioural expectations than radical changes that "violate" the established social order. The sale of fuel-efficient cars is therefore easier to organise than the spread of forms of shared mobility (*ride sharing*), which require people to say goodbye to their own car and the routines of individual mobility (Clausen & Fichter 2016). This highlights the fundamental problem of sustainable innovations: They not only require the replacement of individual products or processes with other technologies that function in a similar way, but usually deviate so strongly from the status quo in terms of their orientation that they also require a change in the interpretive patterns that guide people's actions (automotive freedom of private transport), ingrained practices (flexible patterns of movement and planning) and corresponding structures (forms of housing, infrastructures, regulations).

General innovation research focuses less on the significance of system innovations for social change than on the significance of individual product and process innovations for the economic development of a country and its companies or – viewed the other way round – on the consequences of a lack of innovative capacity for economic development. According to Schumpeter (2021 [1911]), who is regarded as the founder of innovation research, innovation processes are primarily determined by entrepreneurial personalities and the possibility of obtaining loans for innovation development. Both factors determine whether a potential innovation (*invention*) can be successfully established in a company and, based on this, in society or on the markets (*diffusion*) in order to initiate a "process of creative destruction" through which the existing is intermittently replaced by the new. The innovation drivers or "promoters" in the organisations must succeed in presenting the innovation as a convincing improvement and then initiate an adaptation process through which the new becomes so adaptable with the old that it changes the old.

As a branch of business administration, innovation management is dedicated to overcoming internal and external barriers to innovation by providing strategic support for innovation processes and their promoters in order to move quickly from initial ideas to successful market penetration. However, the challenges of supporting sustainable innovations are greater: Not only must they be successfully promoted and implemented, but they must also remain true to their original aims, i.e., they should *not* adapt particularly well to the (unsustainable) existing situation, but rather continue to pave a transformative path forward towards greater sustainability. This objective often requires the deliberate disregard of short-term success factors in favour of long-term transformation goals, which, considered individually, are radical, uncertain, controversial and volatile, as illustrated by the debate surrounding electric cars. Within this debate it is even considered a success if an electric car is purchased as a second or third car (regardless of the overall ecological impact), which stabilises rather than transforms unsustainable lifestyles.

This may be one reason why sustainable innovations are rarely driven by large market players and established research and development laboratories, but mostly by explicitly ecologically motivated industry newcomers, start-ups, niche players and so-called eco-pioneers. At the same time, these two contexts tend to result in different types of sustainability innovations. In established companies and organisations that develop technologies, the incentives for innovation processes are guided by commercial considerations, so that their output is dominated by incremental adaptation and innovations that improve the sustainability of existing technologies – typically in response to new regulations or changes in market demand. "Radical" innovations, which are associated with high costs and a major risk of failure, are avoided. More fundamental innovations dedicated to sustainability are therefore typically driven by government interventions, a high level of commitment and clear sustainability objectives (Fichter & Clausen 2021), or by "change agents", "visionaries" and innovative user communities, including private individuals from the civil society sector (Ornetzeder & Rohracher 2013). They specifically strive for sustainable change and generate alternatives as a response to a development model that is perceived as threatening.

Fichter and Clausen (2016, 2021) consider the role of market power, compatibility, policy- and path-related factors (economies of scale, capital commitments, lock-in effects) and industry effects from the perspective of evolutionary economics in order to explain the different the degrees to which sustainable innovations are successfully diffused beyond communication processes. They identified different types of diffusion and sustainability paths and found that efficiency-enhancing and easy-to-understand improvement innovations developed by established companies lead to faster market penetration and tend not to be dependent on government support, but are associated with higher ecological rebound risks. In contrast, the diffusion of more radical and fundamental environmental innovations is lower and slower, especially if they are associated with a high need for behavioural change and place higher demands on users. However, their potential for ecological change is greater. As a result, while fundamental key innovations

for sustainable development are more likely to come from exogenous drivers and players, sustainability innovations from actors with experience in the sector and tried-and-tested sales channels will achieve better market penetration.

In most cases, sociological research is not only interested in individual processes that lead to the development, diffusion and establishment of new technologies or social arrangements, but also in overarching innovation processes, as well as the systems, milieus, regimes and networks involved in innovation, and their socio-cultural prerequisites and social effects. The sociology of innovation is not limited to the economic sphere, but encompasses all social fields of action and their various innovation processes and groups of actors. In the following section, we therefore continue our exploration of the opportunities for sustainable innovation with a focus on network formation in scientific and technological innovation processes from the perspective of *Science and Technology Studies (STS)*.

4. Innovation networks and alliances

Disney's *Gyro Gearloose* characterised the image of the ingenious but naive (garage) inventor for entire generations: While he could build a faster-than-light spaceship within a few days if necessary, innovation processes are rarely the result of the genius of individual actors. Rather, they require cooperation across organisational boundaries and involve existing instruments, technologies, financing options and connecting factors. This cooperation results in innovation networks that are sometimes implicitly and sometimes explicitly used. If an innovation process is successful, all the actors involved in the network change their (starting) positions, motives and criteria, and existing material and technical artefacts are reshaped in favour of an innovative "new combination" in the words of Schumpeter or "new composition" in the words of Latour. This process of transformative network formation requires the modification and reorganisation of all components, both human/social and technical/material. Actor-network theory (ANT) traces how these processes develop along a meandering *trajectory* and uses the concept of "translation" to consider the individual modification steps (Callon 1984). The concept of "translation" indicates that innovation processes do not seamlessly transform an initial state into a new state, but rather, as with translations from one language into another, they are associated with adjustments, changes and new meanings that do not necessarily correspond to the original intentions (→ chap. 3 on society-nature relations). Reductionist notions of scientific "discoveries", individual "ideas" or technical "improvements" and their subsequent "application" or "implementation" are thus rejected. Instead, ANT ethnographically traces how new scientific interpretations, social arrangements and technical possibilities emerge in a heterogeneous web of relationships and assert themselves as innovative socio-technical networks – or don't (Latour 1996). On the one hand, this approach takes up the findings of research on the *social construction of technology (SCOT)*, which has used many individual case studies to examine how the processes used to create technologies are influenced by relevant social groups and their ideas and expectations (Bijker et al. 1986). On the other hand, as part of its "symmetrical" approach, it also takes into account the role of technological influencing factors,

material effects and natural resistance: "The social 'material' and the technical 'material' are both relatively malleable and the successful innovation is the one which stabilises an acceptable arrangement between the human actors (users, negotiators, repairers) and the non-human actors (electrons, tubes, batteries) at the same time" (Akrich et al. 2002a: 210).

From this perspective, an innovation appears as an interdependent process that connects several components, in which the formation of scientific descriptions (e.g., of electricity), technological applications (electricity grid, lightbulb) and arrangements for their use (electricity consumption) are mutually co-constructed. The focus of the investigation is therefore on how it is possible to stabilise an evolving network in which different actors, interests and abilities to act are linked (Latour 2005). It is only through successful connection that "*collaborative*" new "associations" of a shared world can emerge, whereby the roles of nature and technology, innovators and users, network and actor, innovation and adaptation cannot be clearly separated from one another. Michel Callon (1984) described this process of relational inclusion in a much-cited study on the emergence of a new process for the cultivation of scallops: Relational inclusion is the result of moments of translation in a heterogeneous innovation process, through which the human and non-human actors, communities, identities and affordances involved are connected and modified until a new process gradually takes shape through the networking and modification of all elements. Callon describes the initial emergence of a common problem and the naming of relevant groups as the *problematisation* of the status quo, which must be followed by the integration of relevant perspectives, materials, technologies and actors (*interessement*) into an alliance in order to successively establish mutual relationships and define roles (*enrolment*), which ultimately leads to the *mobilisation* that is critical for the successful further "representation" (i.e., stabilisation) of the innovative arrangement (cf. Figure 11). Other case studies also show that this network formation does not proceed in a linear fashion, but via detours and crossroads, and is often not successful – it is hindered or prevented by the failure of shared visions and alliances, as well as by the opposing strategies of individual "dissidents".

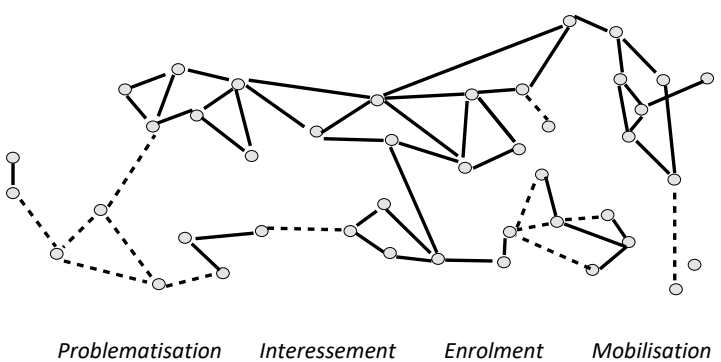

Figure 11: Network-like innovation processes; source: own illustration based on Callon (1984) and Akrich et al. (2002b)

The work of technology historian Thomas P. Hughes (1983) is similarly structured. His comparative study of the electrification process in major cities in the United States, Great Britain and Germany and the resulting infrastructure systems is considered an important work of innovation research. Hughes examines how gas lamps in private households were replaced by Edison's lightbulb and electricity, not because the technology was superior or because Thomas Edison was a brilliant inventor, but because he was a skilful "*system builder*". In addition to developing technically useful devices, he also succeeded in initiating corresponding supply systems, organising financing options and winning over relevant decision-makers. Edison problematised the risks of gas lamps, gathered together the relevant people, mobilised social, material and financial resources for the new infrastructure and successfully stabilised his supply system by also "representing" the needs of companies, consumers and the authorities – all before developing the technical applications. By assembling these heterogeneous components, which John Law characterised as "*heterogeneous engineering*" (Law 1986), Edison enabled the development of a new, relational network ("*seamless web*") of electrification and helped to stabilise the emerging infrastructure system in the face of resistance and alternative proposals through continuous adjustments that were not only technical, but also financial, discursive and legal (Hughes 1986). In this way, he initiated a complex socio-technical system that not only interdependently changed the lighting technologies, but also the legal norms, political power relations, billing models and other components in support of a new, common system goal. In the ambiguous title of his book, Hughes (1983) describes the emerging supply systems as "*networks of power*" and thus links the development of technical infrastructure systems with the associated emergence of political spheres of influence. Innovations, he tells us, are not a question of technically or socially superior ideas, but must, in order to be successful, transform social reality and rearrange socio-technical configurations through the formation of innovative alliances.

Two important conclusions can be drawn with regard to the development and implementation of sustainable innovations: Firstly, innovation processes cannot be planned and "implemented" by individuals, but require supra-individual networks and successful stabilisation: "Innovation is perpetually in search of allies. It must integrate itself into a network of actors who take it up, support it, diffuse it" (Akrich et al. 2002a: 203f.). It is therefore not enough for environmentally conscious scientists or activists to develop sustainable solutions to problems; the new compositions must assert themselves within a network of socio-technical components and require a variety of adjustments and mutual compromises. Secondly, innovation processes cannot be intentionally designed from one perspective, but depend on these successful links – they and their contexts change unpredictably and interdependently throughout the multi-branched introduction, implementation and stabilisation phases. Many sustainable innovations, such as meat substitutes for vegetarian lifestyles, are therefore disappointing in terms of their sustainability balance when they ultimately end up as industrially manufactured consumer goods in supermarket refrigerators. ANT refers to this comprehensive process that is full of surprises as "socio-technical transformation"

(Akrich et al. 2002b: 212). However, neither Hughes, Callon nor Latour were initially specifically concerned with sustainability innovations, although all three authors later turned their attention to this problem and emphasised the need to take non-human actors into account for the successful long-term interaction of everything on Earth.

Research on non-technical innovations, such as the introduction of the first paper currency and the establishment of voluntary fire brigades by Benjamin Franklin (Mumford 2002) or the current emergence of municipal, sustainable energy supply systems (Smith et al. 2016), also emphasises the necessity of successful network formation and the mutual adaptation of technical and social systems. In particular, innovations that deviate from the established social order and question its frameworks that guide action (as is generally the case for sustainable innovations) face the problem of having to build a countercultural network and assert themselves against the powerful existing alliances. To do this, they are usually dependent on windows of opportunity during which established approaches are called into question, and on protected spaces in which sustainable solutions can first be trialled before they are exposed to competition with the non-sustainable mainstream. These insights are summarised in the multi-level perspective presented below, which has been taken up primarily in *transition research* over the last ten years.

5. Innovations and the different levels involved in the transformation of unsustainable practices

Transition research refers to a variety of research approaches that examine ways of supporting the transition processes which will lead to sustainable societies. They adopt different perspectives to describe, evaluate and promote transitions in the energy, agricultural and transport industries and their possible contributions towards social change that will lead to greater sustainability (→ chap. 10 on transdisciplinarity). This broad field is also not interested in individual innovation processes. Instead, it focuses primarily on the innovation-relevant interactions between the established, non-sustainable systems and the various sustainability-oriented or "transformative" approaches and strategies and their socio-economic and institutional frameworks.

In the Netherlands, a widely recognised heuristic method called the *multi-level perspective (MLP)* has been continually developed since the late 1980s (see Figure 12). It incorporates concepts from actor-network theory, evolutionary and institutional economics and governance research (Kemp et al. 1998). It analyses opportunities for sustainable innovation and transition processes, viewing them as relational, co-evolutionary and long-term processes that result from multifaceted changes in the configuration of socio-technical systems (Geels 2002; Grin et al. 2010). It sheds light on the interactions between groups of actors from different sectors and disciplines, from the societal micro-level to the societal macro-level, as well as the possibilities for these interactions to fundamentally change the established socio-technical system. The MLP thus also pursues a decidedly

non-deterministic perspective that understands technologies as a place for the organisation of social change, not as its driver, even though it has addressed the implementation of innovative, technological problem-solving processes in great depth. Drawing on studies about innovation trajectories – i.e., the specific trajectories of innovation processes (see section 2.) – the multi-level perspective instead assumes three interlinked levels of innovation development with different cycles of change, between which a multidimensional interplay of radical niche innovations, stabilised problem-solving patterns and long-term change evolves (Grin et al. 2010).

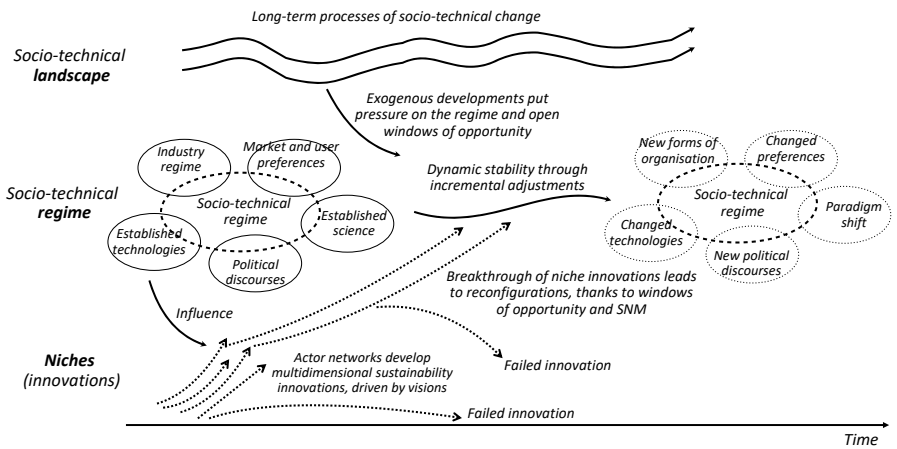

Figure 12: Transition processes from the multi-level perspective (MLP); source: own illustration based on Geels (2002: 1263)

- The concept of the *regime* lies at the centre of this perspective. It describes a stabilised socio-technical system of actors, products, technologies, specialist knowledge and corresponding routines and cultures related to demand, as well as political lobbying networks. In regimes, the various interests are balanced and the necessary organisational processes are firmly established. The existing infrastructures are adapted to suit the regime, as are the formal, moral, and cognitive rules. Examples of such regimes include the automotive industry or the mainstream food system, the various dimensions of which are all consolidated and therefore almost impossible to change.
- In contrast, promising sustainability innovations can only emerge at the lower level in *niches*, i.e., on the fringes of established problem-solving patterns. In these niches, the aforementioned *change agents* consciously experiment with alternative, countercultural strategies and initially allow their results to circulate in the protected space of ecologically oriented milieus or neighbourhoods until they are capable of competing with mainstream strategies. Examples include the early days of solar and wind energy development, mobility pioneers, and organic farms.

- The exogenous, socio-technical *landscape* is the overarching level of analysis that looks at societal trends and developments that characterise the use of resources in the long term. At this level, crises and disasters can call the status quo into question, opening up the windows of opportunity that are necessary for change. However, this level remains conceptually diffuse and forms the weakest part of the MLP.

The concept of regimes has long played a role in diffusion research. It has been used to describe different configurations of conditions in which innovations are implemented. Two examples of this include "routine regimes" in highly concentrated markets with strong path dependencies, in which large capital-intensive companies in particular have an advantage in relation to innovation, and "entrepreneurial regimes" in which smaller, fast-learning companies (e.g., in the music and culture industries) enjoy special innovation opportunities (Acs & Audretsch 1987). This research has also shown that the handling of knowledge and the strategic organisation of new forms of knowledge are important for the success of innovations. If these findings are transferred to sustainable innovations, it becomes clear that so-called *incumbents* (i.e., the well-established regime actors) avoid the necessary handling of uncertainties and complexities. However, they have sufficient resources to take up challenges such as following the guiding principle of sustainable development, primarily symbolically, without actually initiating a comprehensive and continuous sustainability process (Blättel-Mink 2006: 90). Instead, by continuously launching incremental innovations, they contribute to dynamic stability within the established socio-technical system, in which the prevailing frameworks that guide action change only gradually. New knowledge for sustainability innovations, on the other hand, tends to be contributed from external sources by "eco-pioneers" in niches (Blättel-Mink 2006: 89), as mentioned in the first section.

The MLP focuses on analysing the complex innovation and transition processes, which are characterised by intended and unintended interactions with the established nexus of prevailing infrastructures, habits, thought patterns, logics that guide action, actor configurations, policies, economic practices, and forms of regulation. For this reason, its scope of investigation goes beyond the organisational level of individual innovations and primarily encompasses the significance of high degrees of institutionalisation and how this shapes relevant path dependencies, legal and financial framework conditions and their historical development. The socio-technical status quo's forces of inertia – together with their institutional anchoring in market power, standards, consumer preferences and educational content – are countered by sustainability-oriented visions, learning processes and alliances that cannot emerge in the mainstream, but only in niches that are more strongly shielded from these institutions. With the *strategic niche management* (SNM) approach, the authors of the MLP were interested in exploring how sustainable innovations from the "green" pioneer milieus can successfully penetrate the dominant regime network of industrial market and actor configurations, canonised knowledge, established solution expectations, economic

and consumption patterns and the unquestioning continuation of unsustainable relations with nature.

This approach emphasises that compatible "co-evolutions" are needed to support the success of sustainability innovations – for example, corresponding political regulatory impulses that open the door to sustainability goals within existing legal and cultural regulatory systems. The basic thesis of the multi-level perspective is that as long as overarching processes of change do not create pressure to adapt within the regimes or windows of opportunity for the development of sustainable innovations within the niches, the regimes will cause sustainable innovations to largely adapt to the established modes of problem solving. For a few years now, this research heuristic has also been further honed with concepts from political economy regarding the resilience of dominant actor configurations in industry and politics (*incumbent actors*) (Geels 2014): Since then, increased attention has been paid to the close capitalist alliance of decision-makers in politics and business and the well-resourced, definitional, techno-economic, governmental and regulatory ways in which they assert their interests to ensure the system remains profitable for them.

For this reason, research on transition processes initially examined the development of sustainable innovations by strategically looking at the provision of protected spaces in learning niches, in which the innovations can be successfully developed and tested through network-like support outside the established regime (Kemp et al. 1998). Accordingly, the strategic niche management (*SNM*) approach investigates how sustainability experiments can improve the performance and diffusion of potentially transformative innovations through networking, the development of visions and social learning that reinforces positive expectations (Kemp et al. 1998; Schot & Geels 2008). It is argued that the progress of sustainable innovation processes can be supported and stabilised by anticipatory decision-making in the political arena that is geared towards long-term goals, as well as by the articulation of sustainability visions that guide action, the formation of overarching networks, and comprehensive training and learning processes (Kemp & Loorbach 2006; Grin et al. 2010). However, this research has made it increasingly clear that strategic niche management alone is not enough to establish sustainable innovations in the face of the existing regime. Transformative sustainable innovations are also dependent on political support (*niche policy advocacy*), accompanying forms of advocacy from intermediary organisations and convincing transformation discourses (Smith et al. 2016), as well as the targeted delegitimisation of unsustainable solutions and the forging of subversive innovation networks, which are often instigated by civil society (Smith et al. 2016; Köhler et al. 2019). Above all, however, it is becoming increasingly clear that these kinds of innovations benefit from the deliberate "destabilisation" of existing regimes by means of transformative political instruments at a superordinate level (Kivimaa & Kern 2016).

In recent years, the multi-level perspective approach has often been applied to energy transitions, the successful implementation of which requires not only innovations in renewable energy generation and storage technologies, but also

far-reaching political, financial, organisational and social changes, including innovative forms of governance and control. The implementation of these innovations and changes has been far too slow, which illustrates not only how difficult such far-reaching transformation processes are, but also the long-term obstacles facing the multitude of interlinked transformations that are required before a project like the energy transition actually leads to measurable sustainability changes. A transformation can only be considered socially accepted and routinised when the established approaches and institutional orders have been replaced by newly created socio-technical regimes. This involves a change in thinking, acting and regulating, because the transformative practices must go beyond the "semantic" level of discursive and symbolic changes and reach the "pragmatic" level of new practices and routines, and also change the "grammatical" level (Hutter et al 2015: 37) of the (infra)structures and rules that guide action. From a multi-level perspective, a *transition* to a different, more sustainable regime configuration is therefore synonymous with changes across all the levels in one sector (energy supply, mobility), from the innovating niche (photovoltaics, electric cars) through to the entire socio-technical regime (energy or mobility systems) and the overarching social macro level (post-fossil fuel society).

6. Outlook

As innovation research has taught us, even individual innovation processes for sustainable development are far-reaching and complex projects that have to contend with considerable "initial disadvantages" compared to (unsustainable) innovation processes in the established socio-technical system. A transformative breakthrough that will contribute to the general development of sustainable innovations and a sustainable society is necessarily made up of many small and some fundamental transformational steps. The transformation will involve both incremental and radical innovations: Some will be deliberately designed to address perceived risks or changed demands, while others will be the surprising results of the networks that are formed in response to the constraints and disasters caused by environmental and climate change (→ chap. 5 on risk and conflicts about risk). It should be emphasised that the effects of innovation and transformation processes cannot be predicted. They are made up of direct and indirect, intended and unintended changes and adoption processes, and are accompanied by social upheavals that result in further innovation and adaptation processes. After decades of social science restraint in relation to intentional societal transformation, researchers are increasingly interested in the targeted management of long-term transformation processes and the associated imagined futures (→ chap. 10 on transdisciplinarity). This raises questions about the legitimacy of the competing futures, their subjects and objects, the transformation regimes, as well as ideas about transformation goals and justice from a global perspective. To date, transition research has primarily focused on the structural barriers to sustainable innovation and transformation processes in Western industrialised countries; despite the SDGs presented in the introduction, these barriers have not yet been sufficiently investigated in conjunction with the living conditions and scope for action in the global South.

It is incredibly important that environmental sociologists continue to research sustainable innovations. The need for contributions from sociology will become ever clearer as modern societies increasingly recognise how comprehensively we need to think about sustainable innovation and transformation processes, and how small the contribution of technological innovations is (even though it is important that technological innovations are anchored in socio-technical transformation processes and connected with processes of social change). Sociologists can also help to correct the "*innovation bias*" of the engineering sciences in favour of further research into exnovations. This would require working out not only how sustainable approaches and supply systems (e.g., renewable energy sources) can be introduced, but also how unsustainable practices and technologies (e.g., the generation of electricity from coal) can be simultaneously abolished, in order to make society truly sustainable (Kivimaa & Kern 2016; Davidson 2019).

What students can take away from this chapter:

- Knowledge about innovation processes and their trajectories
- Knowledge about sustainability goals and the difficulties involved in related innovation processes
- Knowledge about diffusion research
- An understanding of the characteristics of innovation processes and networks
- Knowledge about sustainability-orientated transformation processes
- Knowledge about the multi-level perspective (MLP)

Recommended reading

Kivimaa, P. & F. Kern, 2016: Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions. *An article worth reading that uses the energy transition strategies in the UK and Finland to show why sustainable innovations are not enough and why unsustainable regimes must be destabilised at the same time.*

Rogers, E.M., 2003: Diffusion of innovation. *A classic of diffusion research that explains the importance of different communication and diffusion channels.*

Schot, J. & F.W. Geels, 2008: Strategic niche management and sustainable innovation journeys: Theory, findings, research agenda, and policy. *A presentation of how the diffusion of sustainable innovations can be specifically supported.*

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Chapter 9: Infrastructure systems – A determining factor in society-nature relations

Overview

In this chapter, you will find out about how infrastructure systems are created and how they shape society-nature relations in the long term. You will learn about their central characteristics which make them highly resistant to change. We will demonstrate how attempts to reshape our systems of mobility, food or energy supply bring about conflicts, are based on visions of desirable futures, and must contend with path dependencies.

Infrastructures are supply systems, social institutions and technical facilities that are intended for collective use and, as socio-technical foundations, predetermine the social, economic and ecological living conditions in a spatially specific manner. Infrastructure systems consist of (material) technical networks such as roads, railways and waterways, electricity lines, and supply and disposal facilities, as well as (immaterial) social institutions such as educational, health and other welfare institutions, as well as an institutionalised, politically negotiated operational organisation with a high level of legal regulation and a special financial framework (e.g., taxes or levies that are incurred independently of usage fees). As the foundation of modern welfare states, infrastructure systems also encompass norms and standards that influence their patterns of development (keyword: path dependencies) as well as place-specific "utilisation knowledge", for example about what can be expected from the healthcare system and how to behave on public transport. They are often summarised by the term "*public services*". Without their existence and the socio-technical conditions they provide, individual households could hardly survive, nor would private sector activities be competitive or modern societies be able to function politically: Infrastructures enable the functioning of modern societies. Tangible material infrastructure systems contain economic capital, many years of investment, technical devices and expertise, industry standards, and a multitude of material resources. The intangible components include institutions and services, as well as the legal, technical and political knowledge required to operate and maintain them. With their high capital requirements and long service life, infrastructures outlast political and technological change, are unquestionably assumed to be a public good for all kinds of activities, and yet are constantly being remodelled and expanded. They are omnipresent yet mostly invisible, collective yet not free of charge. Infrastructure policy is typically legitimised by the creation of modern living conditions (Edwards 2003) and social justice. Since the 1990s, ecological issues relating to the unsustainable external effects of infrastructure development have also become increasingly important. Until that point, infrastructure development had been viewed as an economic growth policy. It is becoming increasingly clear that infrastructure conditions must be viewed as a key factor in terms of climate impact and the specification of ecological material flows (Monstadt 2009).

Infrastructure systems are significant, not only ecologically, but also because they are spatially and temporally expansive and extend across multiple sectors. Despite this, they were not addressed in environmental sociology for a long time. The question of why modern societies jeopardise their environment and transform it in ways that threaten their existence has tended to focus on people's lack of environmental awareness or knowledge, or on incorrect individual behaviour, counterproductive incentive systems and cultural orientations that stand in the way of sustainable behaviour (→ chap. 4 on environmental attitudes and action, and chap. 7 on sustainable consumption). Reference is also made to the compartmentalised internal rationalities of societies that are functionally highly differentiated, follow imperialist traditions, and are characterised by capitalist growth imperatives (Brand & Wissen 2018). The technologies and system complexes perceived as particularly problematic, such as those involved in food and energy supply or transport, are the focus of many studies due to their direct and indirect environmental impacts. However, the fundamental role played by long-lasting infrastructure systems as both an expression of society-nature relations and a determining factor of those relations and the practices they enable has not been systematically analysed for a long time. This requires greater sociological attention, particularly in view of the politically initiated "transitions" in the energy, mobility, and agricultural sectors.

Against this background, we will first discuss the characteristic features of infrastructures. We will subsequently present the challenges of redesigning infrastructures in the context of socio-ecological transformation processes and then look at the social conflicts that the redesigning of infrastructures entails.

1. Characteristics of infrastructures

Unlike the concepts of "network" or "system", which also refer to the connections and interdependencies between different elements, the concept of infrastructure is not well established in sociology. This may be related to the fact that the discussion of infrastructures is generally regarded as a technical matter whose social character only becomes apparent at second glance. Another reason may be that infrastructures are perceived as rather "boring" and often remain "invisible", as emphasised by the American sociologist Susan Leigh Star, who has dealt extensively with infrastructures and their social effects (Star 1999; Bowker & Star 2000). The term infrastructure is a French neologism, a collective term that firstly always denotes a plurality of integrated components and secondly refers to an "underlying", heterogeneous structure that makes superordinate projects possible: *infra* is the Latin word for below / under / underneath (as opposed to *ultra*). "Infrastructure" differs from the terms network or system due to this focus on a heterogeneous socio-technical foundation, which consists of both technical and social components. The term was adapted in English in the context of railway construction to refer to the necessary organisational and preparatory work that precedes the actual rail construction, i.e., decisions about routes, tunnels, stations, bridges and the material foundation of the rail bed (Carse 2017: 27). It has always been a relational term that refers to the interdependence of social,

technical, physical and financial dynamics and focuses on their necessary linkage and practical maintenance for the economy and society (Star & Ruhleder 1996: 113).

The most widespread perspective on infrastructure in sociology comes from Susan Leigh Star: "People commonly envision infrastructure as a system of substrates – railroad lines, pipes and plumbing, electrical power plants, and wires. It is by definition invisible, part of the background for other kinds of work. It is ready-to-hand. … [But given the bottlenecks and constraints that infrastructures create] We were forced to develop a more relational definition of infrastructure, and at the same time, challenge received views of good use of ethnography in systems development. We began to see infrastructure as part of human organization, and as problematic as any other" (Star 1999: 380). Accordingly, infrastructures are understood as socio-technical arrangements whose readiness for use is the precondition for social practices, which usually remain inconspicuously in the background, but organize standards and practices. This means that they represent structures that, in the etymological sense of the prefix *infra* described above, lie beneath social practices and form their foundation, but unlike technical devices such as cars or mobile phones, are rarely the subject of direct interaction (Larkin 2013: 329; Shove 2017; Shove & Trentmann 2019). Nevertheless, infrastructures have far-reaching effects as determining factors behind social and environmentally relevant practices. For example, the practice of showering is based on a socio-technical arrangement of water pipes, heating systems, wastewater disposal and recycling facilities, forms of organisation, expectations about cleanliness, and financing models (Bell 2015), the existence of which is perceived as predetermined and ignored in everyday showering, but which "pre-structures" the practice of showering. In this respect, infrastructures set standards and shape conventions that narrow the scope for further decision-making on several levels: a) As a background condition, they only allow certain technical and organisational linkages, so that, for example, fuel cell vehicles cannot become widespread without petrol stations that sell hydrogen. b) They create horizons of expectation that, like conventions, invisibly standardise social practices in the background. c) They are linked to cultural horizons of interpretation, for example by setting and maintaining standards for differentiating and classifying things, and such standards are also nested within one another and therefore difficult to dismantle (Star & Lampland 2009).

Due to its barely perceived impact and the multidimensionality outlined above, it is not surprising that the concept of infrastructure has remained vague in sociology and that it is difficult to draw boundaries around it (Larkin 2013: 329). For example, what is transport infrastructure? Is it primarily roads, traffic lights and railway lines? Or do maintenance systems, road traffic regulations and technical inspection agencies also need to be conceptually included? What about modern poetics of mobility? What significance do national borders and regional differences have for transnational infrastructures and what conventions are typical for different countries? It is neither meaningful nor possible to determine definitive answers to such questions. In infrastructure research, it is the specific

object of investigation and the respective research interests that determine where boundaries are drawn and which aspects are taken into account.

However, in recent decades a consensus has emerged in social science infrastructure research regarding a number of defining characteristics that should generally be taken into account. Depending on the research perspective, other aspects may also become more important (Hughes 1983; Star & Ruhleder 1996; Star 1999; Shove et al. 2015).

Socio-technical hybridity: The main defining characteristic of infrastructures is their hybridity. Infrastructures are inevitably heterogeneous hybrids that are the result of both material and social components. In his study "Networks of Power: Electrification in Western Society", which is fundamental to infrastructure research, the technology historian Thomas P. Hughes (1983) showed how the construction, conversion and dismantling of infrastructures depend on the art of forging stable networks from heterogeneous material, technical, financial and symbolic components. Hughes analysed electrification in Chicago, New York, London and Berlin historically and comparatively in order to reconstruct how access to electricity was implemented as a large-scale socio-technical supply system. The study shows that electrification was only able to replace gas as a source of energy because technical artefacts and social conditions became related to one another and mutually adapted; in other words, the power lines, markets and processes of coal-fired power generation became networked with important actors, expectations and organisations in a way that was typical for each nation. In the process, socio-technical systems emerged in North America, the UK and Germany that each produced different standards, financing and organisational structures as well as power structures – just as Hughes' ambiguous book title "Networks of Power" suggests. Hughes emphasises the organisational skills of Thomas Edison, one of the inventors of the lightbulb, who succeeded as a "system builder" in successfully linking social, material and technical resources to create a seamless web that facilitated the creation of complex infrastructure systems. His research led him to establish the "system approach", according to which infrastructures and their transformation should always be viewed as the temporary result of the integration of heterogeneous material and social components into a system.

Invisibility: Another central feature is the aforementioned *transparency* or invisibility of infrastructures. This refers to the way that infrastructures disappear into the background of the utilisation practices that they make possible. In general, for example, users do not ask themselves whether and how the transport network, the water supply or the internet will still be available tomorrow and what conditions are necessary for them to function. As Susan Leigh Star and Geoffrey Bowker put it: "The easier they are to use, the harder they are to see" (Bowker & Star 2000: 33). In fact, infrastructures are not present in individual and social consciousness as long as their functionality can be assumed – even if they are accompanied by ecological and social upheavals. They only become visible as a prerequisite of social life when they break down. Then it becomes clear how dependent modern people in particular are on these collective socio-technical foundations. Dirk van Laak (2023) accordingly describes infrastructure failures

as activating unconscious fears because they make hidden vulnerabilities and dependencies tangible and often produce forms of impotent rage. When transport systems fail, it not only affects people's mobility – the economy also comes to a standstill. Power failures fundamentally jeopardise society's ability to function and are capable of triggering cascading disasters in almost all areas.

Relational mediation agencies: On the one hand, infrastructures form the basis of almost all actions and, on the other hand, are only relevant as long as they function and are used. A few decades ago, telegrams were used to communicate the most important messages, but today teleprinters and telegraphic infrastructure have long been forgotten. It is true that infrastructure systems shape social practices, such as mobility or consumption, by structuring how they are regularly carried out in socio-technical terms. But they collapse when their functions fail or social practices turn to other infrastructure systems, as is the case today with the shift towards renewable energy sources (Gross & Mautz 2014; Watson & Shove 2023). They therefore mediate between structure and practice, and do so in a reciprocal and interrelated manner. What is relevant here is their interconnectedness with a variety of different practices, so for example, the water supply is used equally for showering, cooking, the provision of drinking water and garden irrigation. A reorganisation of infrastructure or a symbolic reinterpretation of its central elements therefore entails far-reaching, systemic changes, affects a large number of people, and brings forces of inertia to light.

As infrastructures always enable certain practices and exclude others, they must also be viewed as political projects that are also linked to distribution issues. Their study is interesting because infrastructures reveal "technopolitics" (Larkin 2013), as well as geo-spatial politics and political decisions underlying the socio-technical foundations of society (Coutard & Florentin 2024). They define social participation and opportunities for participation, open up certain development corridors and close others, determine environmental consumption and channel both supply and demand structures as well as the social expectations, standards, and identities associated with them. Therefore, infrastructures not only materialise expectations about the future; they themselves also have an impact on the future and are at least temporarily irreversible (Barlösius et al. 2011: 164). They can even be regarded as political instruments: Infrastructures are instruments of political control, but they are often presented as politically neutral or apolitical because their design and implementation can be presented as purely technically justified, even though they are based on political ideas and intentions and have corresponding consequences (ibid. p. 166). Infrastructure projects are therefore an integral part of nation-building, they are never finalised and are integrated into complicated processes of coordination and the balance of power. The design of infrastructures is not only orientated towards technical feasibility and dominant social practices, needs or expectations, but is also influenced by the implicit and explicit visions, conventions and interests of planners, designers, and decision-makers (Shove et al. 2015: 284), what the term "infrastructuring" emphasises (Coutard & Shove 2024).

Obduracy: Infrastructures are built up over long periods of time, can only change slowly, encode spaces and create path dependencies. They materialise social standards and ideas about normality and allow certain connections, while complicating or interrupting others. As a result, infrastructure systems cannot easily be changed and adapted to new goals, but are instead resistant, obdurate and "hardened" in technical, social and institutional terms (Hommels 2005). That is why ecologically necessary reforms and renewals such as energy and mobility transitions are so difficult. For example, automobility is stabilised as the predominant form of mobility by the underlying infrastructure of built transport routes, social norms about spatial flexibility, technical standards of motorisation and spatial development, and institutional regulations that stipulate how many parking spaces must be provided on or near new buildings which turn public spaces into car parks. Abandoning such an established infrastructural path is associated with high costs. At the same time, research also shows the influence of collective shifts in meaning and (aggregated) practices on infrastructure development, suggesting a potential for infrastructure plasticity (Watson & Shove 2023).

Infrastructure development, its path dependencies and forces of inertia are a central issue for socio-ecological transformations due to infrastructure's socio-technical interconnectedness, its invisibility, its mediating effects on social practices, and its resistance to rapid change. We will take a closer look at this in the next section.

2. Infrastructures and their forces of inertia

The often promised and hoped-for "decoupling" of economic growth and prosperity on the one hand, and resource consumption and environmental damage on the other, has not yet been sufficiently achieved. The inertia of the existing supply systems and the norms that are built into them privilege the status quo, so that even dedicated sustainability innovations fail to achieve their goals of a) making societal development sustainable through novel solutions to problems and b) bringing about intra- and intergenerationally sustainable modes of living and production. Electric vehicles, heat pumps, photovoltaic systems or car sharing do have the potential to reduce problematic resource consumption and climate-relevant emissions. However, the current infrastructure conditions stabilise unsustainable "normalities" and routines at an underlying level, for example with regard to the focus on single-family homes and private motorised transport. As a consequence, individual sustainability innovations often tend to lead to substitution, rebound, and addition effects (Sonnberger & Gross 2018) (→ chap. 4 on environmental attitudes and action, chap. 7 on sustainable consumption and chap. 8 on sustainable innovations). Reductions in consumption facilitated by new technologies are then partially cancelled out or even overcompensated by additional or alternative consumption. Infrastructures can therefore be regarded as "socio-technical systems" or "technostructures" whose stability and obduracy stand in the way of socio-ecological transformations.

The concept of "socio-technical systems" is helpful for understanding how and why large-scale technical infrastructures, which feature multiple linkages, are resistant to change (Edwards 2003). A socio-technical system is defined as a tightly linked ensemble of technical, institutional, organisational and social arrangements, practices and relationships that are held together by their interdependence. Transition research also describes the interplay between technical conditions, socially anchored usage norms, and the associated knowledge, organisational and usage cultures as a "socio-technical regime". Overcoming such regimes requires external windows of opportunity and alternatives that have been tested in protected niches (Geels & Kemp 2007) (→ chap. 8 on sustainable innovations). The socio-technical regimes at the core of infrastructures attain their stability through their historically developed and constantly rebalanced social and technical linkages. On the one hand, these linkages enable infrastructures to operate continuously without further thought or reflection, and on the other hand, are robustly opposed to socio-ecological transformation attempts.

Large-scale technological systems with structures that extend across space and time are contributing to the fact that resource consumption and emissions are falling too little and too slowly in relevant fields such as mobility, energy, housing and food to avert the catastrophic effects of climate change or even meet politically defined targets – despite increased environmental awareness and numerous sustainability innovations. Their forces of inertia play a decisive role in determining the form and depth of intervention in society-nature relations (Monstadt 2009). As the basis of social and economic life, particularly in cities, infrastructures not only "channel" resource flows, but also shape ecologically relevant structures of expectation and everyday practices, and determine the design of technologies and innovation processes. Infrastructural resistance is encountered wherever there are attempts to introduce sustainable economic and consumption options: Although it may be ecologically better to walk, cycle or use public transport instead of cars, socialised expectations regarding motorised individual transport stand in the way. Renewable energy sources could be utilised in a variety of ways, but their integration into existing supply arrangements poses numerous reconfiguration problems. Even the partial replacement of individual components in existing infrastructure systems collides with "hard" system constraints and leads to opportunity costs and interface problems, as demonstrated by the sluggish spread of heat pumps or the difficulties of taking bicycles on trains.

Due to this hardening or *obduracy* (Hommels 2005), infrastructures block isolated changes that only take effect at one level – for example, at the level of consumer practices, technologies, usage rules, connections or interfaces. As such, infrastructures require complex system transformations (Hughes 1983). Any redesign of infrastructures in line with environmental goals therefore faces the multifaceted task of having to make changes in a system with multiple linkages that is held together by underlying guiding principles and norms as well as by technical instruments and compatibilities, associated technical knowledge, the natural environment, and culturally determined user behaviour (Grin et al. 2010). A targeted transformation of infrastructures therefore faces the challenge of hav-

ing to reconfigure self-evident factors that have been stabilised in many ways. In recent decades this has been confirmed by the ongoing energy transition in many Western countries, which was desired by citizens and driven forward by politicians. The implementation of renewable energy sources is taking longer than hoped, causing technical and social adjustment problems and raising opposition at various levels. All of this must be considered in relation to the interplay between the various components: Electricity supply and billing modalities must be redefined, past investments in technologies such as coal-fired power plants and heating systems become "sunk costs", new manufacturing and operating expertise is required, new networks and supply lines must be established across borders, and old sensitivities and balanced conflicts of interest must be taken into account. Entire sectors are being restructured, ministries are taking on new responsibilities – but from the consumer's perspective, the depth and breadth of the necessary changes are at best only marginally visible.

Despite the many linkages, the continued existence of infrastructures also hangs by a thread in terms of their usage or the ways in which they are used (Star 1999: 380). As described above, infrastructures have a strong practical relevance, as they serve as the basis for different practices, often interlinked with further infrastructures. However, if those practices are no longer carried out, the underlying infrastructure systems decay and are forgotten. For example, if certain energy sources are abandoned, entire infrastructure systems become superfluous. The cessation of brown coal mining leads to the abandonment of open-cast mining sites, the respective business locations and the associated jobs, and has a profound impact on the regional environment and living conditions – from the development of new recreational areas to emigration and economic decline in the affected communities. A significant change in the number of vehicles or the demand for heating would inevitably result in similarly far-reaching and climate-relevant changes to existing (currently unsustainable) infrastructures. To a certain extent, infrastructures could be dissolved virtually overnight through a lack of usage, as the telegram example illustrates. However, there are only a few examples where the radical dismantling of infrastructure has led to fewer supply requirements, resources, emissions, and impacts rather than more. Infrastructure systems are much more frequently expanded, upgraded or at best reorganised.

It is also relevant that there are virtually no persons or parties in charge of infrastructure development, precisely because of its overarching importance and its many components ("nobody is really in charge of infrastructure"; Star 1999: 382), and that only disruptions to infrastructure "draw attention to problems that are important for the context of functioning" (Luhmann 2012 [1984]: 318). As Niklas Luhmann emphasised, the dependencies that develop in the shadow of infrastructure networks mean that "any breakdown of technology (especially energy supplies) would also lead to the breakdown of our familiar society. In other words, technological development has led to innumerable *nonnatural self-evidences*. We take it for granted that the cistern will refill when we flush the toilet" (Luhmann 2012 [1984]: 321f.). Once infrastructure systems have been established, they lead a life of their own that eludes social attempts to organise

or design them, even though they are permanently subject to repair and maintenance.

In the engineering sciences, it is often assumed that questions of infrastructure design are solved technically and that society must then be familiarised with the new solutions. Meanwhile in the social sciences, numerous case studies in Science and Technology Studies (STS) have shown the extent to which social forces determine infrastructure development. Central to this are perceived possibilities and imagined futures that enable coordination across different areas of action (Jasanoff & Kim 2015). Shared ideas about desirable futures bring actors together and they align their activities towards a common goal (Wentland 2016). Infrastructures are always both existing and inadequate at the same time; their reorganisation is geared towards the future and anticipated future demands (Edwards 2003; Shove 2016). Infrastructure development projects are thus embedded in a narrative of progress in the future perfect tense (the completed future) (Hetherington 2017: 40). As proof of the state's ability to act (van Laak 2023: 17-19), they articulate a welfare promise for the future: When this infrastructure project is completed, it will improve the conditions for more successful technologies, actions, opportunities for participation, and sustainability. Future infrastructure promises are also used as arguments in the context of spatially and socially unequal development, in which nations and cities compete as business locations by promising better facilities, supply networks, etc.

Rather than viewing infrastructure in terms of its supposed stability and inherent necessity, the term "infrastructuring" captures the assembling, maintaining and stabilising efforts that infrastructure requires. In contrast to the static concept of infrastructure, the term "infrastructuring" is intended to emphasise the processual nature of the construction and ongoing maintenance of infrastructure systems and thus point out that they are not simply "there", but are always "in flux". For example, the road transport network is constantly being maintained, expanded and, in a few cases, dismantled or reverted back into space for public interactions. Considering the variety of processes, strategies and interests involved, it is not surprising that infrastructuring is often characterised by conflict and fierce design controversies, during both the design and construction phase as well as the continuous maintenance and adaptation phase (Coutard & Shove 2024). Only from a long-term perspective do the processes of infrastructuring lead to stabilised socio-technical systems with corresponding socio-economic path dependencies. We would like to conclude our discussion about the obduracy of infrastructures by highlighting three stabilising factors (Hommels 2005).

Firstly, these are collective orientation schemes which, depending on the sociological perspective, shape infrastructuring either as dominant patterns of thought or interpretation, guiding principles, institutionalised structures of action and expectation, or systems of rules. They manifest themselves as culturally anchored, shared ideas (*imaginaries;* Jasanoff & Kim 2015) about goals, problems and conditions for action that transcend actor groups and only allow certain changes to appear legitimate and sensible, while other options are ignored. With regard to the emergence of car-friendly cities, Cliff Ellis (1996), for example, examined

how American road engineers were able to assert their "professional worldviews" (which they formed in relation to the development of rural areas) in the planning of urban motorways for inner cities over the opinions of critics from architecture and urban planning, who had less legitimacy. Firstly, they benefited from the ability to use computer models and statistics to establish simple and coherent rules and define them as standards. "Their texts dryly catalogued the rules for successful technical performance, purged of ambiguities" (Ellis 1996: 273). Later on, even though these standards were widely criticised, they could no longer be revised due to fragmented responsibilities, complicated conflicts about objectives and controversial detailed proposals. As Ellis states: "Professional worldviews are not transparent lenses, but refracting prisms. They enable people to act, but also prevent them from seeing avenues for action" (1996: 278). Established ways of thinking structure the energy transition in many countries in such ways that socio-technical solutions are selected according to traditional planning and legitimacy concepts and aligned with the dominant model of a centralised energy supply. For an example, the same applies to the principle of centralised energy supply enforced in Germany, which resisted alternative proposals despite all the conflicts surrounding grid expansion and decentralisation – even though decentralisation could be implemented in a technically and ecologically sensible way, particularly in the electricity sector (Gross & Mautz 2014).

Secondly, regimes play a key role as an expression of the multiple linkages of infrastructure development and their embedding in interdependent complexes (Grin et al. 2010, see also chap. 8 on sustainable innovations). Once stabilised, the linkages connecting different components in socio-technical systems make it difficult to change prevailing supply solutions through the use of alternative solutions. Thomas P. Hughes in particular emphasised this effect of the systematic links between "people, ideas and institutions, technical and non-technical", which led to a "super-system" (Hughes 1983: 140). The spatial and temporal expansion of infrastructures with their ever-increasing number of linkages reinforces the *momentum* of the powerful complexes of mutually stabilised properties, rules, interests, and interfaces. In order to renew infrastructures so that they are more environmentally friendly, various components in various subsystems must be re-configured simultaneously – and alternative proposals generally lack the power, competences and resources to do this. Frank Geels (2014) describes how the coal industry's established alliances and the coal-oriented policies that lie at the heart of such a regime in the UK were able to prevent the transition to low-emission technologies, even though there were alternatives available that were assessed as more ecological. These alliances were able to evade the pressure to respond to climate change by strategically influencing the discourse surrounding the problem, materially prioritising certain technology development options over others (such as carbon capture and storage as a "bridging technology"), and institutionally committing policymakers to certain governance styles. In light of these forces of inertia, sustainability researchers widely believe that exogenous forces (so-called niche players) can, at best, implement the sustainability innovations developed by innovative outsiders with sophisticated strategies by establishing their own

networks and development milieus (Grin et al. 2010) (→ chap. 8 on sustainable innovations).

Finally, there are the notorious path dependencies (Unruh 2000, 2002; Seto et al. 2016). They only partly involve technical and social restrictions, are partly found in various forms of capital commitment, and are regarded as forms of material resistance. In evolutionary economics, which is inspired by evolutionary biology and attempts to explain economic change through the interactions between different actors, path dependencies have been described as unintentional commitments made in early phases that limit change caused by factors within the economic system (i.e., endogenous change), and thus also limit the diversity of later development processes. Such path dependencies result from past decisions that are difficult to revise and their impact on capital commitment and debt, investments, network and scale effects, critical mass phenomena and routine-forming learning effects, all of which favour adherence to technological development paths and the expansion of existing structures over the possibilities of creating new paths. An infrastructure industry that makes good profits with climate-damaging technologies in a growing global market is unlikely to change. At worst, such path dependencies contribute to a "lock-in" of established infrastructure and behavioural paths, because subjects acting rationally (keyword: "homo oeconomicus") decide to continue with the status quo regardless of alternative models, even if this turns out to be the wrong decision (Unruh 2000).

Given that infrastructures function outside of our conscious awareness and are only problematised when our expectations regarding their flawless functioning are not met, it is difficult to mobilise forces for their restructuring. For this reason, decisions relevant to infrastructure often remain hidden and only seem to concern a small group of experts, even if they place dispositions that favour certain regimes over other, possibly more sustainable options in the long term. Infrastructure failures and resource-related disruptions, such as the oil crises of 1973 and 1979/1980 or foreseeable cost increases, bring the far-reaching dependencies to light and lead to severe and often antagonistic reactions among those affected. A more recent example of this is the Yellow Vest protests that took place in France in response to the higher taxation of fuels, which was part of the government's attempt to finance and implement the energy transition.

3. Conflicts related to infrastructuring

There is no shortage of attempts to reorganise or replace existing infrastructure systems. The politically initiated "transitions" (e.g., in the energy, mobility and agricultural sectors) are large-scale examples of this, which are accompanied by a multitude of smaller-scale efforts (e.g., more bicycle-friendly infrastructures). These reorganisation efforts make infrastructures "visible" and the subject of public controversies. Conflicts arise over the selection of the right design, the appropriate components and their contested assessments. The conflicts are based on mutually contradictory proposals regarding the best possible arrangements as well as on very different concerns. They are also characterised by the inertia

described above, in which unequal interests and power relations are embedded. Added to this is the fact that industrial growth targets in infrastructure development have largely lost their legitimacy, but new binding norms have not yet taken their place (Kropp 2018a). In this institutional vacuum of culturally binding rules and in light of the organisational fragmentation of responsibilities in liberalised markets that has become typical of infrastructure projects, either the status quo prevails or major conflicts break out over the aims and implementation of infrastructure restructuring and demolitions. A fundamental reconfiguration is made even more difficult because there is a lack of clear decision-making structures or shared decision-making norms (Wolsink 2018) upon which the transition can be built. Rather, the multitude of perspectives, their heterogeneous references and the "indivisibility" of the objects of conflict create conflict configurations in which conflicts cannot be resolved simply by reconciling two different perspectives – instead, they give rise to a multidimensional conflict structure. The disputes revolve around the underlying definitions of the problem and the models for solving it, as well as the distribution of scarce goods, opposing interests (related to usage and avoidance), irreconcilable values, disputed understandings of roles, recognition, power, identity, and legitimation. Thus, disputes about infrastructure transitions exhibit all the causes of conflict known in the social sciences (→ chap. 6 on environmental conflicts). Conflicts of interpretation, interest and legitimation are particularly prominent in infrastructure conflicts, alongside conflicts about knowledge, values, and justifications. The three main types of conflict in infrastructure debates are outlined below:

a) **Conflicts of interpretation** are sparked by controversial problem diagnoses and involve divergent imaginaries and judgements about desirable objectives. For a long time, the mobility transition was dominated by conflicts over drive technologies, political incentives and competition between the various modes of transport. Behind this lay fundamental conflicts of interpretation regarding the problems of private motorised transport and the appraisal of its consequences. More recently, (primarily) economic actors have proclaimed the end of the combustion engine. This has far-reaching consequences for mobility infrastructure (e.g., charging stations for electric vehicles instead of petrol stations) and has eased debates about the various drive technologies. In terms of energy supply, conflicts about restructuring existing infrastructure continue to be fed on several levels by the deep conflict between proponents of decentralised supply solutions (with governance that is more fragmented and more strongly oriented towards supply autonomy) versus those who cling to centralised supply structures (with a necessary grid expansion). At the same time, the assessment standards are shifting as a result of the European climate measures and the restructuring taking place in the respective countries.

It goes without saying that path dependencies play a key role in these conflicts: previous investments justify the effort required to adapt; established technologies, from radiators to cars, enforce compatibility. There is also fundamental disagreement as to whether environmental problems can be overcome at all through better technology (in other words, a technologically optimised "business as usual"

approach), or whether they require a fundamental change in awareness with a radically reduced need for resources. Even if there is consensus regarding the need for change, conflicts still arise about which new infrastructures are more sustainable, better suited to existing business models, and how the transition should be structured. Some interpret energy transitions as a fundamental change in infrastructure and a revolutionary shift towards a "regenerative society", while others see it as a new business area with unchanged framework conditions. The associated allocation of responsibility is also controversial. Should the case be made for a decentralised energy transition at the community level with hopes of self-sufficiency, or should there be supra-regional and state supply guarantees? Are global environmental and economic changes a reason for building local resilience and decision-making autonomy, or are vulnerabilities, especially in peripheral locations, a reason for improving nationwide and international cooperation? In view of the opposing viewpoints, the normative conflicts over local infrastructure projects are often highly emotive – what some see as proof of the credibility and sincerity of particular claims, others see as dubious. Conflicts of interpretation can ignite over technical, economic, social and ecological issues and usually make emotions run high, because it is almost impossible to negotiate between the various parties due to fundamentally different understandings of reality and situations.

b) But **conflicts of interest** also mean that infrastructure restructuring is fraught with conflict: In many cases disputes centre on whose interests should be prioritised (e.g., user, operator or investor interests). Is it necessary to protect vested interests, for example with regard to long-lasting consumer goods such as heating systems and private vehicles, and if not, how can the individual conversion costs be absorbed in a socially just and politically acceptable way? How should the costs of infrastructure restructuring be distributed, who should bear certain burdens and who should receive relief? And how much should current generations pay for infrastructures that will only be profitably used in the future (such as the 5G mobile communications standard, which will primarily benefit cyber-physical forms of production)? Conflicts between ecological and economic interests and between more ambitious and often more expensive modernisation approaches compared to smaller end-of-the-pipe solutions (e.g., filter systems) are of course particularly relevant for environmental sociology. In addition, there are controversies about infrastructure changes that favour technologies which contain lucrative business prospects for some, but disadvantages for others (wind power, hydrogen, passive houses). Conflicts related to usage are also highly significant, especially when it comes to visible infrastructures in public spaces. For decades, there have been disputes in city centres about the fair distribution of street space, i.e., about the proportionality of the different space requirements in transport infrastructure, including between pedestrian and bicycle traffic, stationary and moving traffic, as well as about possible uses of inner-city areas as public space, for example as spaces for retail, gastronomy, social interaction, playgrounds or parks (Carmona 2010).

Conflicts of interest result from the need to select technical, financial, social, and organisational options, each of which have different implications and can also

have indirect consequences in other areas. Conflicts of interest lead to debates about suitable incentive schemes and implementation steps and about strategies for containing any undesirable interactions and consequences. The debate centres on whether or not economic windfall gains are intended, how urgent climate protection and climate adaptation measures are in comparison to other infrastructure projects (for example in the education and health sectors), as well as how to assess the progress that has been achieved so far. The greater the potential threat posed by the consequences of climate change, the more critically the suitability, planning and implementation of previous measures is assessed. In the battle to reduce carbon dioxide emissions, most people consider a renewable energy supply to be the most important building block, but at the same time there is debate about which areas of action are most likely to reduce emissions first. The experimental and not yet fail-safe nature of many approaches to infrastructure restructuring makes it difficult to reach agreement on possible approaches and tends to support their postponement over the known tasks of ensuring long-term public services. Conflicts of interest often translate into conflicts about resources and are therefore an expression of the controversial negotiations involved in socio-technical arrangements, the choice of components, their composition and the associated organisational issues of management, financing, and legal regulation. They follow the lines of power of well-established regime configurations as opposed to those of challengers with novel approaches to solutions. And these gruelling conflicts can erupt in relation to each individual element that needs to be changed in the supply arrangements.

c) Finally, infrastructuring processes can also trigger **conflicts of legitimacy** – this is where unresolved conflicts of interpretation and interests come to a head. These conflicts over the fundamental legitimacy and acceptability of infrastructure changes are well known from research on new technologies and technology impact assessments. They primarily erupt when decisions need to be made or when new infrastructures are implemented, but smoulder from the start of development projects until well after those projects are up and running. They always involve questions about a) what constitutes an acceptable justification, b) specific measures and their justification in relation to alternatives and other necessities, as well as c) the underlying principles guiding the path to the future. Should uncertainties be seen as a justification for postponing system reconfiguration or as a reason for its experimental, participation-orientated design? How are reconfigurations to be legitimised in relation to the status quo: with knowledge or technical ability, qua expertise or with reference to majorities and political/administrative mandates? The conflicts are further fuelled by the need to deal with uncertainty, a lack of empirical data, the dilemma of expertise and counter-expertise and the profound realisation that earlier problem-solving patterns are partly responsible for today's problems. This leads to widespread complaints about a lack of clear objectives, reliable planning standards and continuity in terms of the implementation measures (e.g., for the energy transition). Many parties to the conflict therefore wish to re-establish clear frameworks that guide action and create overarching standards – ideally through public consensus rather than legislation. Faced with an uncertain future, conflicts are generated and promoted by the lack of regulatory

guidelines, the erosion of culturally self-evident values and their corresponding knowledge and training structures, as well as the normative questioning of the old consensus on growth and progress.

The perspectives articulated about how to solve infrastructure problems are often unconnected from one another, right down to the smallest details (Kropp 2018b: 196ff.): Overarching coordination is required, but this is not possible due to a lack of shared assessment criteria and comparative evaluations of the proposed measures that would allow the ecological, economic and social effects of different infrastructure systems to be weighed up against each other. Another complicating factor is that infrastructure change requires cooperative processes between public and private actors, but there is often a lack of mutual clarity about the possibilities for and constraints on action. The various parties involved address a large number of different aspects and infrastructure-related issues, but they lose sight of the environmental and climate problem as a multi-sector issue with special challenges: Fragmented into departmental responsibilities, the significance of these challenges across time, space and different sectors takes a back seat to perspectives that are specific to particular sub-systems and sectors. In the heterogeneous infrastructuring carried out by actors from politics, business and civil society, these sector-specific perspectives mean that – regardless of a fundamental willingness to overcome conflicts of interest – cooperation primarily consists of sealing off one's own sphere of action from the demands of others. Without cross-sector legitimacy, the announced infrastructural changes disintegrate into small blockade conflicts of negative coordination that are designed to minimise mutual interdependencies and disruptions to one's own process. In this way, the inertia of the status quo (which is also determined by the balanced forms of resource distribution and the associated interpretive authority) leads to cross-system challenges ultimately being dealt with in the existing frameworks that guide action and determine the division of labour. By categorising the conflicts according to established assessment and justification criteria, they are resolved using the same legitimation strategies that contributed to their emergence.

The design conflicts make it clear that infrastructure projects in the Anthropocene are to be regarded as "wicked problems" (Rittel & Webber 1973). Neither the problems, objectives and solutions nor their evaluation can be clearly characterised as right or wrong. Conflicts about how to legitimately determine the causes of problems and find suitable solutions, as well as about the implications, interactions and path dependencies that need to be taken into account, mean that those involved do not pursue overarching strategies that are capable of consensus. Instead, the conflicting parties pursue various different strategies that are often incompatible. However, if the adopted approaches are increasingly questioned and incompatible approaches are pursued instead (so-called "technological openness"), then we can assume that conflicts about infrastructure projects are not likely to decrease. Instead, they will become more intense and polarised, especially as the need for a solution becomes more urgent.

4. Outlook

Due to the forces of inertia and conflicts described above, infrastructure changes rarely develop as the result of long-term and consistent transformation strategies. Mostly, changes are the small-scale, fragmented and heterogeneous results of necessary, but sometimes unwanted, sometimes cancelled and sometimes undetermined restructuring processes in large-scale technical systems. Even where radical infrastructure changes have been implemented, such as the cessation of nuclear energy production, decommissioning measures have been and will be postponed for a long time into the future (phase-out models, nuclear waste storage issues, etc.). The diversity of conflicts described above expresses this complexity; path dependencies favour the strengthening of economically motivated ways of thinking about efficiency. As a result, the diversity of socio-technical linkages and arrangements is growing – as is the selective influence of economic constraints on them, which tends to stand in the way of sensitivity towards the climate change issues and potential side effects. As a consequence, sustainability-oriented infrastructuring suffers from a lack of addressable governance subjects and standardised design norms. In addition, it is confronted with the paradox of having to deal with considerably increased complexity and its own internal dynamics, as well as an ever-more extreme socio-economic narrowing of options that cannot do justice to the diverse, long-term and threatening interactions and side effects associated with the Anthropocene.

The considerations in this chapter make it clear that infrastructure systems are not monolithic blocks. They are diverse and heterogeneous, full of fractures and contradictions, and these frictions and pluralities also provide starting points for change. For example, car-centric infrastructures give rise to the use of cars for everyday mobility. However, the more these infrastructure systems are used, the less they are able to fulfil private motorised transport's value proposition of freedom and flexibility, as this can no longer be provided in urban congestion. As a result, dissatisfaction with car-centric infrastructures is growing among parts of the population, thereby opening up opportunities for change. Civil society and economic niche players are addressing these fractures and contradictions in infrastructure systems with the aim of changing them. This gives rise to horizontal actor networks and multilateral arrangements that are being investigated by parts of academia in the form of transformative real-world laboratory research (→ chap. 10 on transdisciplinarity). Within these real-world laboratories, the infrastructure conflicts that inevitably arise in the course of socio-ecological transformations can be observed and dealt with in a co-constructive manner. All in all, infrastructure conflicts provide environmental sociology with an interesting area of investigation that will enable us to better understand processes of change in the relationship between technology, society, and nature. However, they also require critical sociological monitoring so that social inclusions and exclusions, contradictions and possibly unintended side effects arising from infrastructuring processes can be taken into account at an early stage.

What students can take away from this chapter:

- Knowledge about what is meant by infrastructure systems and infrastructuring
- Knowledge about the complex relationship between infrastructures and society
- An understanding of infrastructures' resistance to change
- An understanding of the controversial nature of infrastructure change

Recommended reading

Bell, S., 2015: Renegotiating urban water. *A multifaceted examination of urban water supply and the socio-technical difficulties involved in its sustainable transformation.*

Coutard, O. & E. Florentin, 2024: Researching infrastructures and cities: Origins, debates, openings. *Provides a comprehensive introduction to the study of infrastructures and the various traditions and concepts.*

Hughes, T.P., 1983: Networks of power: Electrification in Western Society, 1880-1930. *A classic of social science infrastructure research and environmental and technological sociology as a whole.*

Star, S.L., 1999: The ethnography of infrastructure. *A much-cited article on the characteristics of infrastructures and their power to shape society.*

van Laak, D., 2023: Lifelines of society. A global history of infrastructure. *An easy-to-read introduction to infrastructures and their national and cultural significance.*

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Chapter 10: Transdisciplinarity in environmental sociological research

Overview

In this chapter, you will find out more about the relationship between environmental research, society, and politics. You will learn about different concepts and understandings of science that characterise problem-oriented research in the environmental field. We will focus primarily on the research principle of transdisciplinarity, which is based on integrating the knowledge of different scientific disciplines and non-scientific actors. You will develop an understanding of the challenges, strengths and weaknesses of problem-oriented, transdisciplinary research.

Socio-ecological crises and socio-technical transformation processes pose major challenges for our societies. They make it necessary to a) translate scientific findings about causes, drivers and solutions into societal problem-solving strategies, and b) align scientific knowledge processes with societal needs and demands. This kind of translation forms the core of transdisciplinary research – it is highly complex and challenging, and does not somehow occur automatically, as will be shown below.

The various subsystems within a society, such as science, economy, politics, law, civil society and mass media, all mutually influence one another (Luhmann 2012 [1984]). Society and everyday life are increasingly influenced by science ("scientification of society"), but society also places demands on science and calls for innovations and solutions to problems ("politicisation of science") (Weingart 1999a). Various authors assume that the interpenetration between science and society is increasing. This is initially an empirical question, the answer to which is highly controversial (Weingart 1999b). In addition, some of these authors go further and suggest that this increasing interpenetration between science and society has led to a normative demand that scientific systems must, at least in part, adapt to these new conditions. This demand is usually made against the background of intensifying socio-ecological crises such as anthropogenic climate change.

The concept of transdisciplinarity describes both the diagnosis of the shift taking place in science and a normative project of adaptation to changing problems that is considered necessary. Here is a general definition that encompasses both the normative and diagnostic aspects of the concept of transdisciplinarity: Transdisciplinarity describes a form of research in which the focus is on dealing with concrete social problems (problem orientation) and which is carried out cooperatively between different scientific disciplines (interdisciplinary orientation) and with the involvement of non-scientific actors (transacademic orientation) (see, for example, Hirsch Hadorn et al. 2008). The term transdisciplinarity thus denotes a research principle (and not a method or methodology) that goes hand in hand with a specific organisational form of science (Becker & Jahn 2006: 320). In transdisciplinary research, the focus is always on concrete societal (i.e., real-world) problems. Transdisciplinary research can be understood as a reaction to the progressive fragmentation and specialisation of the scientific system, which is increasingly

at odds with complex, systemic problems that transcend disciplinary boundaries (e.g., anthropogenic climate change or microplastics in the world's oceans), as well as to the growing social demand for scientific expertise in solving real-world problems. There are two different understandings of transdisciplinarity. Although they both fundamentally agree that transdisciplinarity refers to the collaboration between different scientific disciplines to tackle real-world problems, they differ with regard to their view of the relationship between science and society. One understanding sees transdisciplinarity as a purely internal scientific principle (Mittelstrass 2018), which aims to overcome disciplinary boundaries and integrate disciplinary paradigms. The other emphasises the necessity of involving non-academic actors in the research process in order to generate socially robust knowledge (see in particular Gibbons et al. 1994 and Nowotny et al. 2001). The latter understanding of transdisciplinarity as cooperation between academic and non-academic actors is more widespread today and also forms the basis of this chapter.

In the following section we will look at the origins of the concept of transdisciplinarity, which date back to the 1970s, and briefly outline the relevant debates from that decade, as the topics of those debates have continued to come up in subsequent debates on transdisciplinarity ever since. We will then introduce the concepts of *Mode 2* and *post-normal science*, which laid the foundation for the dominant understanding of transdisciplinary research in the 1990s. This understanding of transdisciplinarity has been taken up by social ecology and concretised in an application-oriented way to become the discipline's guiding research principle. We have therefore devoted one section of this chapter to social ecology. Finally, we will present the concept of transformative science, which builds on the established understanding of transdisciplinarity, but claims to go beyond it.

1. The origins of the concept of transdisciplinarity

The term transdisciplinarity first came to prominence in 1970 at a meeting of the Organisation for Economic Co-operation and Development (OECD) in Paris on the subject of interdisciplinarity. The creation of the term is usually attributed to Jean Piaget, a prominent Swiss psychologist (Bernstein 2015). At this conference, Piaget advocated an understanding of transdisciplinarity in which transdisciplinarity is characterised by a higher degree of integration of scientific knowledge from different disciplines than is the case with interdisciplinarity. In transdisciplinary research contexts, the boundaries between scientific disciplines become blurred or even dissolved, and a kind of holistic unified science can emerge. In Piaget's words: "Finally, we may hope to see a higher stage succeeding the stage of interdisciplinary relationships. This would be, 'transdisciplinarity', which would not only cover interactions or reciprocities between specialised research projects, but would place these relationships within a total system without any firm boundaries between disciplines" (Piaget 1972: 138).

Following on from Piaget, in the 1970s the systems scientist Erich Jantsch, a co-founder of the Club of Rome, developed his own concept of transdisciplinarity

as a normative organisational principle for universities that explicitly takes into account the value-based nature and social embedding of science so that universities can contribute to solving the major challenges facing humanity (Jantsch 1970). Jantsch's concept is also based on the idea of a unity of the sciences. He aimed to overcome the disciplinary fragmentation and specialisation of the sciences by having universities establish cooperative and coordinated structures in teaching and research that transcend disciplinary boundaries. This should ultimately lead to a synthesis of different disciplinary epistemologies, whereby interdisciplinary theories and concepts can emerge (Jantsch 1970: 412). Linked to this is Jantsch's normative claim that universities should contribute to "social renewal": "Essential is only that inter- and transdisciplinary organization and coordination of science are necessary for education and innovation to follow the purpose of society's self-renewal" (Jantsch 1970: 416). To this end, the entire university system should be structured in such a way that disciplinary boundaries are dissolved. For Jantsch, transdisciplinarity is thus: "The coordination of all disciplines and interdisciplines in the education/innovation system on the basis of a generalised axiomatics (introduced from the purposive level) and an emerging epistemological pattern" (Jantsch 1970: 411). In comparison to Piaget, whose concept of transdisciplinarity refers to an extended form of interdisciplinarity (a kind of "discipline-less interdisciplinarity"), Jantsch also associates transdisciplinarity with a normative organisational principle for universities and the associated claim that science should become a social problem solver.

Almost at the same time as Piaget and Jantsch, the German philosophers and sociologists Gernot Böhme, Wolfgang van den Daele and Wolfgang Krohn formulated the thesis of the "finalisation of science" (Böhme et al. 1976), which is interpreted by some as anticipating the sociological debate on transdisciplinarity that took place in the 1990s (Weingart 1997). They understand finalisation to mean that objectives which are external to science – political, economic or social – are increasingly becoming the driver of scientific development and scientific progress. In the process, social needs and scientific interests are increasingly linked, which means that science is increasingly judged from a perspective of usefulness. While Jantsch explicitly makes the normative claim that science should benefit society and can best do this in the transdisciplinary form of organisation, Böhme, van den Daele and Krohn critically point out with their finalisation thesis that a science that submits to objectives that are external to science runs the risk of becoming a tool for stabilising power.

In the contributions from the 1970s that explicitly refer to transdisciplinarity (Jantsch and Piaget) or that refer to it in retrospect (Böhme, van den Daele and Krohn), one can find the key points that characterised later debates about the concept of transdisciplinarity: a) the normative claim that transdisciplinary research is necessary in order to tackle societal challenges, b) the orientation of transdisciplinary research towards dealing with real-world problems, and c) the idea that interdisciplinarity and the associated challenge of knowledge integration is an important characteristic of transdisciplinarity. The integration of non-academic partners that is relevant to today's dominant understanding of

transdisciplinarity was not yet associated with transdisciplinarity at that time. This developmental step in the understanding of transdisciplinarity did not occur until roughly two decades later, as will be described in more detail in the following section.

2. New forms of knowledge production: Mode 2 and post-normal science as conceptual foundations of transdisciplinarity

After the topic of transdisciplinarity received less attention in the 1980s, scientific debates intensified again in the 1990s following the development of the concepts Mode 2 (Gibbons et al. 1994) and post-normal science (Funtowicz & Ravetz 1992, 1993). For many decades, a mode of knowledge production was taken for granted and undisputed in the scientific world, in which research questions were posed in a disciplinary manner and dealt with according to academic quality criteria. In this mode, societal "problems" or challenges were only incorporated in an unsystematic way. Environmental research was also dominated by scientific approaches that drew their legitimisation from internal scientific discourses and stopped at disciplinary boundaries. In the 1990s, this traditional understanding of science was criticised as "academic", "one-dimensional" and "incomplete" and confronted with alternative models of interdisciplinary and problem-oriented knowledge production in order to scientifically address the urgent future issues that are neglected within the traditional model. These alternative models are known as Mode 2 science and post-normal science. While the Mode 2 concept explicitly refers to transdisciplinarity, post-normal science is more implicitly associated with transdisciplinarity. However, both approaches have contributed significantly to sharpening the conceptual contours of the notion of transdisciplinarity and to initiating new debates.

2.1. Mode 2

In their 1994 book "The new production of knowledge. The dynamics of science and research in contemporary societies", the authors Michael Gibbons, Camille Limoges, Helga Nowotny, Simon Schwartzman, Peter Scott and Martin Trow outline the contours of a new mode of knowledge production from the perspective of scientific theory and sociology. They call it Mode 2 in order to clearly differentiate it from the classic form of basic research (Mode 1). Gibbons et al. (1994) describe a shift in knowledge production away from an extra-societal, purely university-based production of "abstract truths" and towards the development of problem-oriented analyses and solution approaches that are related to real-world practices and embedded in specific contexts, and in which a large number of scientific and non-scientific actors are involved. The hitherto internal scientific quality criteria for assessing the quality of knowledge production remain necessary, but are no longer sufficient for lending validity to scientific knowledge. The fundamental argument that Nowotny, Scott and Gibbons set out in their 2001 work "Re-thinking science. Knowledge and the public in an age of uncertainty" (partly in response to the criticism they received) can be summarised briefly as follows: In contrast to Niklas Luhmann's ideas about a progressively functional

differentiation of science, society, politics and the economy, modern societies are experiencing an ever-increasing interpenetration and thus a "de-differentiation" or merging of science and society. On the one hand, scientific knowledge is playing a key role in more and more areas of life. For example, the scientification of nutrition can be observed in popular scientific self-help books. On the other hand, modern societies are increasingly confronted with the negative consequences of scientific and technological progress, which they in turn try to deal with by using science. This is also linked to the fact that society is making increasing demands on science with regard to its usefulness. This argument could already be found in the finalisation thesis presented above and in Jantsch's work. The de-differentiation of science and society has created a new mode of knowledge production (Mode 2), which exists alongside the classic form of knowledge production, i.e., basic research (Mode 1), and is becoming increasingly important. According to Nowotny, Scott and Gibbons, the core element of this new mode of knowledge production is transdisciplinarity as a research principle. Table 3 compares Mode 1 and Mode 2 of knowledge production and illustrates the understanding of transdisciplinarity associated with Mode 2.

Table 3: Comparison of Mode 1 and Mode 2; source: own illustration based on Gibbons et al. (1994: 3), Gibbons (2000: 159f.), Nowotny et al. (2001: 186ff.) and Coghlan (2014: 541)

	Mode 1	**Mode 2**
Problem identification	Disciplinary problem formulation; research oriented towards internal scientific interests	Contextualised, i.e., multi-perspective problem formulation; research oriented towards real-world problems
Actors involved in the research process	Homogeneity: scientists from institutions that conduct basic research	Heterogeneity: scientists within and outside universities, as well as non-academic actors
Organisation of the research process	Hierarchical and stable	Heterarchical and dynamic (project-based)
Quality control	Control system within a scientific discipline	Heterogeneous control system

In the basic research mode (Mode 1), research problems and questions are identified and formulated within the framework of academic disciplines and driven by an interest in scientific knowledge. Each scientific discipline works on problems that arise from gaps in the current state of research within that discipline: It answers scientific questions. In contrast, in Mode 2 problems are identified and formulated by taking into account multiple perspectives. Here, internal scientific and disciplinary interests are not the sole yardstick for assessing the relevance of research problems; societal interests also play a role. Accordingly, science in Mode 2 focuses on dealing with real-world problems, such as those connected

with the effects of socio-ecological crises (e.g., biodiversity loss, microplastics in the oceans, scarcity of raw materials) (Gibbons et al. 1994: 4).

While the actors involved in the research process in Mode 1 form a largely homogeneous group of university-based academics, Mode 2 is characterised by greater heterogeneity. In addition to academics from universities, Mode 2 research processes also involve actors from non-university research and development (e.g., from applied research institutions or R&D departments within companies) and practitioners (e.g., experts from associations, authorities, consultancies or think tanks). While universities are the central players in Mode 1 research, they do not dominate in Mode 2. The shift towards a knowledge society has not only led to society becoming increasingly science-driven, but also to the distribution of research-relevant knowledge far beyond the field of science (Nowotny et al. 2001: 89). Furthermore, Mode 2 research only becomes practically relevant if non-university actors participate in the research process.

The group of actors involved in the research process is primarily related to the organisation of the research process. In Mode 1, the way the research is organised is determined by the hierarchical structure of universities and research institutions, which gives it a certain stability but also rigidity. Research in Mode 2 is organised more heterarchically and dynamically. This means that the research is project-based and takes place in more or less loose networks of heterogeneous players and often without clear or fixed hierarchies. The necessity of project-based work arises primarily from the heterogeneity of the actors involved, who belong to different organisations.

The two modes of knowledge production also differ in terms of quality control. Quality control refers to the evaluation and assessment criteria used to judge the quality of research results. In Mode 1, quality control primarily takes place within the boundaries of scientific disciplines. The assessment of what is considered "good science" follows subject-specific standards. The peers who evaluate and criticise scientific findings and ideas are mainly recruited from the scientific community. Quality control thus takes place within a narrow and clearly defined internal scientific group. In Mode 2 on the other hand, the group of peers is larger and the quality standards are more diverse. Since a large number of heterogeneous actors are involved in the research process and research problems are identified from multiple perspectives, it is no longer possible to clearly determine who can assess the quality of the research results and which standards they can use. In addition, given that Mode 2 is a socially situated form of knowledge production, researchers are not only accountable to their peers (as in Mode 1), but also to the social actors who are part of the research process and in whose environments the positive and negative consequences of the research results are felt. The evaluation of research results is therefore no longer carried out solely on the basis of (disciplinary) scientific standards. Instead, research must also be measured against assessment criteria such as usefulness, dangerousness, desirability, etc., which are used by non-academic stakeholders from politics, business, civil society, and the citizenry, etc. This entails a much more heterogeneous and comprehensive system of quality control.

As the description of the characteristics of Mode 2 suggests, a separation of science and society no longer exists in this form of knowledge production. Science and society are engaged in a mutual exchange and are inextricably interwoven (Latour 1998). They develop in a co-evolutionary way. In Mode 1, if science addresses society at all it is by providing fundamental findings that are taken up and made applicable by companies, political decision-makers, and authorities, etc. However, society now also speaks to science by participating in the identification of research problems. Accordingly, it is not only science that changes society, but also society that changes science. The result is a "context-sensitive" science that produces "socially robust knowledge", i.e., knowledge that is also widely recognised and valid outside the scientific system (Gibbons 1999: C82, 2000: 161). Gibbons et al. consider the risk of such knowledge being doubted or rejected in the context of social debates to be far lower than in the case of knowledge that has been generated in a purely internal scientific research process and subjected to quality control merely within scientific disciplines.

All in all, Mode 2 of knowledge production is based on a changed relationship between science and society (keyword: de-differentiation), which primarily affects which research questions (keyword: problem orientation) scientists work on in collaboration with whom (keyword: transdisciplinarity). What remains open is whether Mode 2 merely represents a sociological diagnosis of changes in the system of science or ultimately formulates a normative claim as to how science should function in the face of far-reaching social challenges. It is precisely this oscillation between descriptive diagnosis and normative claim that has often been criticised (Shinn 2002). Nevertheless, many transdisciplinary projects have taken up the considerations associated with the Mode 2 concept for their problem-oriented research without dwelling on this tension between normativity and descriptive diagnosis. We will go into this in more detail in the last two sections.

2.2. Post-normal science

While Mode 2 and transdisciplinarity are closely and explicitly linked, the connection between transdisciplinarity and the concept of "post-normal science" is more implicit. In the central essays on post-normal science (Funtowicz & Ravetz 1985, 1992, 1993), the term transdisciplinarity does not appear, although there are numerous similarities (Ravetz 2010, p. 244), as we explain below. Alongside Mode 2, reflections on a "science for a post-normal era" (Funtowicz & Ravetz 1993), which deals with questions where facts are uncertain, values are contested, stakes are high and decisions are urgent (Funtowicz & Ravetz 1993: 744), represent an important point of reference in the debate on transdisciplinary research.

The concept of post-normal science was developed in the mid-1980s by the two science theorists Jerome Ravetz and Silvio Funtowicz. According to the two authors, the increase in risks brought about by scientific and technological progress leads to a changed relationship between science and society, in which how we deal with uncertainty and implicit values becomes more important (Ravetz & Funtowicz 1999: 641). The first parallels to the Mode 2 concept can already be seen here. The term post-normal science is an allusion to the concept of normal

science used by the philosopher of science and physicist Thomas S. Kuhn, who distinguishes phases of normal science from those of scientific revolutions in his major work "The Structure of Scientific Revolutions". By "normal science", Kuhn means a mode of science in which scientific knowledge is cumulatively attained through the formation of theory and empiricism within the framework of a dominant paradigm (Kuhn 1996 [1962]: 9). Research takes place on the basis of an established and widely recognised theoretical foundation, and scientific findings are made that build on each other, as they have the same theoretical starting points. Scientific revolutions, on the other hand, are moments when the dominant scientific paradigm within a (sub)discipline comes under pressure due to new approaches and is replaced by a different perspective. According to Ravetz and Funtowicz, since around the end of the Second World War, modern science has had to contend with the fact that its findings and successes are accompanied by growing uncertainties and normative ambiguities[28] – particularly with regard to the consequences of science and technology – which makes phases of normal science in Kuhn's sense increasingly rare (Funtowicz & Ravetz 1993: 740). Uncertainties find their way into science in particular where experiments are not possible and scientific knowledge is instead gained with the help of mathematical models and computer simulations based on partly implicit, normative or uncertain assumptions (Funtowicz & Ravetz 1993: 742). The idea of a value-free science that identifies unambiguous truths is thus increasingly regarded as an illusion.

A further starting point for Ravetz and Funtowicz's considerations is the observation that the negative consequences of science and technology (in particular environmental destruction), which are becoming more and more observable and discussed, cannot be dealt with using the same type of science that produced those side effects. The "old" science would attempt to overcome the negative consequences of science and technology with advances in knowledge within the existing paradigm and technological innovations developed using this knowledge, which would, however, lead to further side effects. Thus, from a societal point of view, the mode of normal science has a self-destructive tendency (Funtowicz & Ravetz 1993: 742).

According to Ravetz and Funtowicz, in order to counteract this tendency, a new, post-normal form of science is needed that addresses uncertainties, reflects on controversial values, is aware of its value-bound nature and takes non-scientific perspectives and bodies of knowledge seriously and integrates them into the research process (Funtowicz & Ravetz 1992: 273, 1993: 741). This leads to a democratisation of scientific practice, or in the words of the two authors: "The activity of science now encompasses the management of irreducible uncertainties in knowledge and in ethics, and the recognition of different legitimate perspectives

28 Normative ambiguity here refers to the value-related ambiguity of a situation or issue. For example, the use of nuclear energy can be assessed as positive and desirable, as it represents a relatively CO_2-neutral source of energy compared to coal, but at the same time the problem of storing nuclear waste and the risk of nuclear accidents also suggest the opposite assessment. How this technology is scientifically assessed therefore also depends on the point of view of the observer.

and ways of knowing. In this way, its practice is becoming more akin to the workings of a democratic society, characterised by extensive participation and toleration of diversity" (Funtowicz & Ravetz 1993: 754).

Compared to Mode 2, the emphasis here is more on the need to democratise science. However, as with Mode 2, it remains unclear whether post-normal science is a normative concept and describes what socially relevant science should look like in order to make a contribution to tackling major human challenges such as climate change, biodiversity loss, poverty, etc., or whether it should be understood as a sociological diagnosis that postulates that a new type of science has emerged or is emerging through its confrontation with scientifically produced uncertainties and risks.

Having initially approached the post-normal science concept in abstract terms, the question now arises as to exactly what type of science is meant by post-normal science. In order to clarify this more precisely, Funtowicz and Ravetz distinguish between three policy-relevant forms of knowledge production and the associated problem-solving techniques on the basis of the two dimensions of "systemic uncertainties" and "decision stakes" (Funtowicz & Ravetz 1993: 744ff.) (see Figure 13).

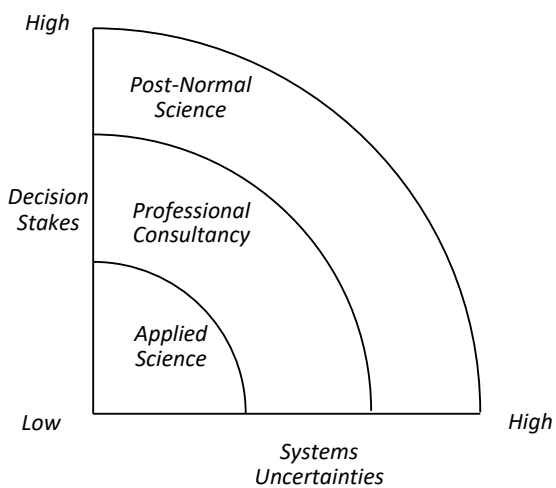

Figure 13: Forms of knowledge production and problem solving; source: Funtowicz & Ravetz (1993: 745)

The "decision stakes" axis describes the extent of the costs and benefits associated with solving a particular problem – i.e., the values that are "at stake" (both economic and social, such as justice or health) and the associated conflicts of interest. For example, the fight against the COVID-19 pandemic can be described as a problem that is a disaster if it fails, but delivers enormous benefits if it succeeds, and is accompanied by major conflicts of interest with regard to the dif-

ferent strategies proposed for solving the crisis. The "systems uncertainties" axis, in turn, represents the degree of complexity of the problem and the associated uncertainties with regard to its assessment. The COVID-19 pandemic, for example, was as an extremely complex systemic risk that encompassed multiple crises (education crisis, economic crisis, health crisis, etc.), for which there were no clear and unambiguous solutions (Funtowicz & Ravetz 1993: 744). The two axes are linked in that, if the level of scientific knowledge is uncertain (high systems uncertainties), the assessment of the level of knowledge depends on the values at stake – and this varies between different groups of actors (e.g., the affected population or political decision-makers) (Ravetz 1999: 650). Among other things, this reflects the aforementioned value-bound nature of science.

Based on these two axes, Funtowicz and Ravetz then distinguish between three policy-relevant forms of knowledge production, as forms of science that contribute findings and solutions for the real-world problems that political decision-makers (have to) deal with. In the field of applied science, the problems to be solved are of low uncertainty and there are relatively clearly defined, unambiguous problem-solving options available in the established body of scientific knowledge (low systems uncertainties), so that there is little room for decision-making conflicts (low decision stakes). Here, established theories and standardised scientific methods can be used to develop reproducible solutions to problems. The field of professional consultancy comprises applied science and also issues that are characterised by greater uncertainty and higher decision stakes. As these are context-related yet more complex problems that are sometimes dealt with on behalf of clients and sometimes on behalf of politics and society, it is not possible to apply standardised problem-solving procedures or recommendations that are beyond question or doubt, because of the many different objectives and assessment criteria. Instead, the solutions that are developed depend on the context, may be risky and cannot be easily reproduced or applied to other problems. Finally, the field of post-normal science is characterised as follows: "The problem situations that involve post-normal science are ones where, typically, facts are uncertain, values in dispute, stakes high, and decisions urgent" (Funtowicz & Ravetz 1992: 253). There are no undisputed theories or reliable methods of problem solving. Instead, possible solutions are highly controversial due to conflicts of interest. The expertise that each interest group puts forward to strengthen its position can be refuted by other groups using their own counter-expertise. Many environmental conflicts take this form (Ravetz 1999: 649). In relation to these three forms of knowledge production, basic research (referred to above as Mode 1) can be located at the intersection of the two axes, because it is determined purely by internal scientific interests: claims or decision-making spaces that are external to science play no role here (Funtowicz & Ravetz 1993: 745).

As scientific findings in the field of post-normal science are subject to great uncertainty with regard to their scope, validity and consequences, they are not perceived as truths by those affected. Instead, values and interests play a significant role in the evaluation and assessment of scientific findings and the problem-solving approaches derived from them. For example, nuclear power is perceived

as a high-risk technology on the one hand and as an effective means of combating climate change on the other. Such problems lead Funtowicz and Ravetz to conclude that quality assurance in the field of post-normal science cannot be carried out solely by internal scientific actors and methods, in particular peer review procedures by other scientists, but that all actors affected by the scientific findings must be involved in an open dialogue to evaluate those findings. In this context, Funtowicz and Ravetz speak of an "extended peer community": "The contribution of all the stakeholders in cases of Post-Normal Science is not merely a matter of broader democratic participation. [...] For these new problems, quality depends on open dialogue between all those affected. This we call an 'extended peer community', consisting not merely of persons with some form or other of institutional accreditation ('stakeholders'), but rather of all those with a desire to participate in the resolution of the issue" (Ravetz 1999: 651). The idea of an extended peer community is also linked to the claim that not only the academic knowledge of scientists should be taken into account in the research process, but that practitioner and lay knowledge should also be included (Funtowicz & Ravetz 1993: 754f.). For example, when dealing with local ecological problems, the everyday knowledge and experience of the local population, who have observed or been directly involved in the development of the problem, is of great importance (Wynne 1996). However, this is not about turning lay people into scientists, but rather about integrating non-academic knowledge into the research process and opening up the discussion and evaluation of scientific findings and proposed solutions to all actors in society (Funtowicz & Ravetz 1992: 254). Funtowicz and Ravetz believe that this is always necessary when, as explained above, a lack of reliable facts means that a particular problem has no clear solutions and any possible solutions are associated with different advantages and disadvantages for different social actors.

2.3. Criticism of Mode 2 and post-normal science

The concepts of Mode 2 and post-normal science have been heavily criticised time and again since their emergence, particularly from the perspective of the sociology of science. Most of the criticism applies equally to both concepts (a brief summary of the main points of criticism can be found in Nowotny et al. 2003: 189f.). The criticism is primarily directed at three points: a) a lack of empirical evidence, b) an insufficiently complex understanding of the relationship between science and society, and c) the subjugation of science to political and economic imperatives.

Peter Weingart in particular argues that there is a lack of empirical evidence for the emergence of a new form of knowledge production and that Mode 2 and post-normal science should be seen as a normative programme for the transformation of science, but not as an evidence-based, descriptive diagnosis of an observable change (Weingart 1999: 48). This is exacerbated by the fact that the fundamental texts on Mode 2 and post-normal science make no clear distinction between normative claims and descriptive argumentation, and their empirical references are also of a more anecdotal, experience-based nature and not based on a systematic analysis.

Furthermore, critics argue that the strong emphasis on the de-differentiation or merging of science and society, which – as shown – can also be understood as a normative claim, has the consequence that existing differences between different bodies of knowledge (especially between lay knowledge and academic knowledge), forms of the division of labour and the different functional logics of different systems (such as science, economy, politics, civil society, etc.) are downplayed and sometimes deliberately ignored (Shinn 2002: 604). The lack of theoretical underpinning for the de-differentiation hypothesis also results in an insufficiently complex understanding of the relationship between science and society.

Critics also take issue with what they see as an implicit assumption in Mode 2 and post-normal science that science should submit to political and economic imperatives and ensure that its findings can be utilised as effectively as possible both politically and economically. Behind the claim of democratising science thus lurks the danger of a neoliberal restructuring of the relationship between science and society (Maasen & Lieven 2006).

While the criticism about the inadequate theoretical and empirical basis of the de-differentiation hypothesis is entirely understandable and justified, we would like to take a more nuanced look at the criticism about the normative orientation and "neoliberalisation" of science. Such criticism is certainly appropriate when researchers in transdisciplinary projects unquestioningly adopt political and/or social guiding principles, e.g., regarding sustainability, resilience or economic viability, or view these as externally given guidelines. It is also problematic if political and/or social guiding principles become established as a set research objective and evade scientific legitimisation and critical reflection. In this case, scientific objectives would actually be subject to non-scientific interests. However, this is not a general problem of transdisciplinary research, as outlined in the concepts of Mode 2 and post-normal science, but rather depends on the context of the specific research project, how the research is embedded within organisations, as well as the researchers' ability to reflect and their scientific diligence.

3. Transdisciplinarity as a research principle of social ecology

Intensifying socio-ecological crises and their public discussion has led to the establishment of a field of research over the last three decades in which environmental problems are not understood and analysed as mere natural phenomena, but as socio-ecological problems. There are various names for this field of research, such as human ecology, integrated environmental research, sustainability research, and social ecology (Becker 2016: 392). In our view, social ecology is the most succinct description.

Social ecology examines the interrelationship and interactions between society and the environment (Becker 2016: 395f.) – not from a purely sociological perspective, like environmental sociology, but in an integrative way. An analysis of social processes of perception and actions is combined with an analysis of the ecological effects and repercussions of those actions. It therefore takes an integra-

tive view of social, technical and biophysical systems, their interactions and the resulting consequences. The contribution of environmental sociology is thereby primarily in the analysis of the relationship between the environment, technology, and society.

Socio-ecological problems (e.g., biodiversity loss or the ecological consequences of car use) are always real-world problems that transcend the boundaries of scientific disciplines and cannot be reduced to objects of investigation within individual disciplines (Becker 2016: 264). Furthermore, they are typically perceived, described and assessed very differently by various scientific and non-scientific actors. As described above, such problem configurations invite a transdisciplinary research approach, which is why socio-ecological research usually takes place in a transdisciplinary mode (Becker 2016: 393f.). In the following, we will provide a more detailed explanation of the transdisciplinary approach in social ecology as it has become established in German-speaking countries and beyond, particularly on the basis of work carried out by the Institute for Social-Ecological Research (ISOE) in Frankfurt and the Department of Environmental Systems Science at ETH Zurich. It is a concretisation of transdisciplinarity as a research principle for scientific practice, which borrows in various ways from Mode 2 and post-normal science.

The central element of transdisciplinary research in social ecology is the concept of knowledge integration. This refers to the need to relate different types of knowledge to each other and integrate them in order to be able to deal with socio-ecological problems. Knowledge integration is necessary due to the multi-layered nature of the research objects and the fact that different disciplines and non-academic actors must be involved in the research process, so that practical and socially relevant solutions can be developed for these complex problems and contributions to scientific knowledge can be made (Jahn et al. 2012). The various actors involved in the transdisciplinary research process possess different knowledge stocks and can therefore also contribute, in varying degrees, to the expansion of knowledge. In the field of transdisciplinary research, a distinction is generally made between the following three stocks of knowledge (Hirsch Hadorn et al. 2008; Becker 2016: 245):

a) System knowledge refers to the relationships and processes that have led to a particular problem. It is a deeper understanding of certain issues and conditions, and compiles factual knowledge about "the current state of play". The concept of system knowledge thus corresponds to the classical understanding of scientific knowledge.
b) Orientation knowledge refers to values and goals that guide action and represents knowledge about the desirability and acceptability of different target states. This is normative knowledge about the direction in which a certain problem state should be changed.
c) Transformation knowledge refers to the way in which a specific target state can be achieved. It describes knowledge about how a current state can be transformed into a target state through practical problem solving.

While researchers are primarily carriers and producers of system knowledge, non-academic actors in transdisciplinary research contexts are mainly responsible for providing orientation and transformation knowledge. The aim of knowledge integration is to bring the various actors together and to relate and link their individual knowledge stocks to one another. This linking is necessary because the solution to the problem at hand is based on the interaction between the various knowledge stocks: Knowledge about a practical solution to the problem (transformation knowledge) can be derived from analytical knowledge about the origins of the problem (system knowledge) and is also dependent on knowledge about the target state that the solution should be aiming towards (orientation knowledge).

The transdisciplinary research process for dealing with real-world problems can be roughly divided into three phases (for more on the transdisciplinary research process in general, see Jahn et al. 2012). In the first phase, the problem transformation phase, a real-world problem is translated into a scientific problem so that it can be addressed by science. A real-world problem is by definition a problem articulated by social actors, so the way in which the problem is perceived and described varies depending on the orientation knowledge of the relevant actors. This means that a precise definition of the problem can only take place with the involvement of the relevant social actors. The constantly high CO_2 emissions caused by motorized individual transport is an example of a socio-ecological, real-world problem, which we will use to illustrate the three phases. This problem must now be translated into individual scientific questions that can be addressed by the relevant disciplines. From a sociological perspective, for example, the social significance of mobility in general and automotive transport in particular could be examined; from an engineering perspective, researchers could focus on questions of (energy) efficiency and the design of passenger transport options with lower CO_2 emissions. In the second phase, the phase of knowledge generation and interdisciplinary integration, the researchers involved in the project work on their respective (disciplinary) questions. What is important here is that the individual questions must be coordinated with each other or already formulated in an interdisciplinary manner, so that they can be brought together to create an interdisciplinary perspective on the problem once the results are available. This creates system knowledge that combines the findings of different disciplines to create the most comprehensive understanding possible of the logic and dynamics of the problem. In the example introduced above, this means that the researchers would develop a comprehensive picture of the social, political, technical, etc. factors that lead to the constantly high CO_2 emissions caused by motorized individual transport. In the third phase, transdisciplinary integration, the researchers work cooperatively to derive and develop problem-solving approaches. These can range from recommendations for action to guidelines or specific products. In transdisciplinary integration, the involvement of non-academic actors takes centre stage because, as the primary carriers of transformation and orientation knowledge, they are best placed to assess the practical feasibility and acceptability of the various problem-solving approaches.

This type of practical transdisciplinary research outlined above has become firmly established over the last two decades. Unlike Mode 2 and post-normal science, it has rarely been the topic of major debates. However, the debate about problem-oriented research practices has been reignited by the emergence of so-called transformative science, some of whose pioneers draw on ideas about transdisciplinarity. In the following section, we will therefore conclude with a look at transformative science and the associated real-world laboratory research.

4. Transformative science and real-world laboratory research

The notions that scientific knowledge production should be democratised and research should be oriented towards real-world problems are inherent to different concepts of transdisciplinarity, and these ideas have gained greater momentum in recent years through calls for transformative science (Augenstein et al. 2024). At the heart of the idea of transformative science is the demand that science should become a catalyst for social transformation processes geared towards achieving sustainability. It aims to initiate, drive and, if possible, accelerate transformation processes by developing and testing technical and social innovations in the real world, with the extensive participation of non-academic actors (especially from civil society). Although it is related to transition research in terms of concept and content, transformative science is different in that it does not "only" want to observe, describe and analyse transformation processes in order to generate system knowledge, but rather wants to actively serve as a driver of transformation processes (Schneidewind et al. 2016; Augenstein et al. 2024).

Transformative science is not the same as transdisciplinarity. It operates in a transdisciplinary mode, but claims to go beyond the goals of transdisciplinary research. Accordingly, Uwe Schneidewind and Mandy Singer-Brodowski (2013) refer to transformative science as "Mode 3" of knowledge production, following Gibbons et al. (1994) (see also Table 3). While transdisciplinary research has no explicit normative commitment to *one* target dimension, transformative science is explicitly committed to the goal of sustainability. This means that the innovations developed through transformative research are always assessed according to their contribution to sustainable development, even if it remains unclear and controversial how this development can be put into action. Transdisciplinary research projects primarily incorporate non-academic actors as consultants, particularly to assist with the definition of the problems prior to the practical research process and with the subsequent development of problem-solving approaches. By contrast, transformative science gives non-academic actors the role of co-researchers in the implementation of the research agenda. Furthermore, while transdisciplinary research aims to contribute to solving real-world problems, transformative science aims to actively change society itself (Schneidewind et al. 2016). This demonstrates an intensification of the claim regarding the de-differentiation of science and society, whereby it must be stressed that transformative science does not demand that the entire science system should be transformative, but instead only parts of it.

The central research format in transformative science is the so-called real-world laboratory in which real-world experiments are carried out. The term "real-world experiment" is borrowed from the work of Matthias Groß et al. (2005) (see also Groß 2006). To analyse different (historical) case studies in which scientific knowledge was applied in real-world contexts, i.e., outside the laboratory (e.g., waste disposal, livestock farming, renaturation projects), Groß and his colleagues developed a typology of experimentation. This typology facilitates a more detailed definition of the characteristics of real-world experiments, in contrast to laboratory experiments (see Figure 14).

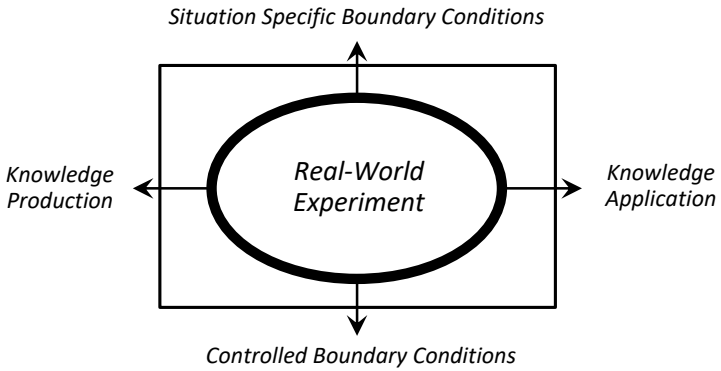

Figure 14: The typology of experimentation; source: own illustration based on Groß et al. (2005: 19)

This typology of experimentation spans two dimensions. The horizontal dimension indicates whether the respective experiment is aimed more at the generation or the application of knowledge; the vertical dimension indicates the degree to which any constraints can be controlled. In this respect, real-world experiments represent a hybrid form of experimentation in which the objectives of knowledge generation and knowledge application are linked and the constraints can only be partially controlled and cannot be systematically reconstructed (Groß et al. 2005: 16; Groß 2006: 47-48). Real-world experiments take place outside scientific laboratories in real-world settings (e.g., in urban spaces), which means that it is never possible to simultaneously control all the factors that could potentially influence the outcome of the experiment. They are also aimed at dealing with specific real-world problems.

The organisational framework for a real-world experiment is the real-world laboratory. Real-world laboratories are concrete locations or contexts such as a neighbourhood, an eco-village, a nature reserve, an energy cooperative or similar, within which transformation processes are initiated with the help of real-world experiments and the resulting interactions between technology, environment and society are made observable (and also influenceable) in situ (Bergmann et al. 2021). The aim is to learn about the transformation processes.

The principles of co-design and co-production are of particular importance in real-world laboratories (Mauser et al. 2013). Both principles represent and emphasise the participatory nature of real-world laboratories. Co-design refers to the involvement of all relevant non-academic actors in the development of the research agenda. Co-production refers to the participatory implementation of real-world experiments and the generation of knowledge, in which civil society actors are involved as co-researchers. How this can be organised and which forms of involvement are justified is highly situation- and context-specific, due to the experimental and performative nature of real-world laboratories. In any case, the classic questions regarding inclusivity and the fairness of the participation processes inevitably arise (Rowe & Frewer 2000). The very specific type of participation that is possible within the framework of narrowly defined real-world laboratory research can also be viewed as problematic, because this runs the risk of losing touch with public controversies and the participation aspirations of certain population groups. The solutions generated in real-world laboratories would then be regarded as sham solutions and not "socially robust". In addition, there is also a risk that real-world laboratory research will take on a strongly instrumental character due to its focus on utility and achieving sustainability, and that critical reflection about the meaning and objectives of experimental activities will be pushed to the background. This also touches on the question of what a critical transformative science could look like (Wittmayer & Hölscher 2017: 93).

Finally, the question arises as to the relationship between transformative science or real-world laboratory research and transdisciplinary research. As already mentioned, it is usually emphasised that real-world laboratory research takes place in a transdisciplinary mode (Schäpke et al. 2018), however, transdisciplinary research and real-world laboratory research have different focuses in terms of knowledge production. Real-world laboratory research focuses on the generation of orientation knowledge and transformation knowledge, while transdisciplinary research focuses on the generation of system knowledge (even though it also takes orientation knowledge and transformation knowledge into account). Accordingly, Thomas Jahn and Florian Keil point out that real-world laboratory research begins where transdisciplinary research ends (Jahn & Keil 2016). Real-world laboratory research can thus be understood as the implementation phase of transdisciplinary research processes, during which it is possible to experimentally evaluate the resulting transdisciplinary knowledge in a real-world setting and find out the extent to which and under what circumstances it is "socially robust".

5. Outlook

Both transdisciplinary research and (transformative) real-world laboratory research on socio-ecological problems fall short without social science expertise, as without it such research fails to take into account the mutual influence society and the environment have on each other. This raises the question of what specific contributions (environmental) sociology can make to transdisciplinary research projects or real-world laboratory projects. Six points can be highlighted in this regard. Firstly, environmental sociology provides theories and concepts about

the interplay between technology, science, society, and the environment, which provide information about underlying interpretations and patterns of action (e.g., lifestyle approaches or practice theories), social structures (e.g., the theory of society-nature relations or systems theory) and their historical development (e.g., theories of social change). These approaches serve firstly to empirically analyse socio-ecological problems and secondly to provide a framework for integrating the findings of different scientific disciplines. Secondly, environmental sociology not only provides specific knowledge about (institutional) procedures and processes for shaping society-nature relations, but also about social forces of inertia (e.g., insights into the role of power in political decision-making processes, about the conditions for action at different levels of society or on the effect of civic participation processes), which are of particular relevance for the development of solutions to socio-ecological problems. Thirdly, insights into the mechanisms involved in the social construction of the environment and environmental risks, as well as the role of value judgements in this construction process, are of particular importance for dealing with socio-ecological problems. In this respect, environmental sociology can draw attention to the variable social character of environmental perceptions and knowledge and thus enable critical reflection on different perspectives during the problem-solving process. Fourthly, in transdisciplinary or real-world laboratory research practices, sociologists can act as process designers who facilitate processes of knowledge integration and, in particular, the involvement of non-academic actors on the basis of their knowledge about patterns of action and interpretation. The discipline of sociology with its understanding of social processes and social interaction is particularly suitable for this. Fifthly, methods of qualitative and quantitative social research are relevant for evaluating the impact of real-world experiments and behaviour-related interventions. That is why this kind of methodological expertise from the field of social research is also required. Sixthly, as a "science of reflection", sociology has the potential to scrutinise and make visible the inevitable but often unconscious selectivity of transdisciplinary processes. The specific design of recommendations for action or socio-technical innovations that result from transdisciplinary and real-world laboratory research always depends on the situational possibilities and circumstances, as well as on the conscious and unconscious decisions made about which non-academic actors are involved in the research process and how. This results in exclusions and blind spots that prevent certain types of recommendations for action and socio-technical innovations etc. from the outset.

(Environmental) sociology can therefore make important contributions towards transdisciplinary research and real-world laboratory research. But what does it mean for environmental sociologists to be involved in such research? Transdisciplinarity and real-world laboratory research go hand in hand with cooperation and exchange with other scientific disciplines and non-academic actors. This makes it necessary to present one's own concepts, terms, theories and methods in a way that is understandable to others and to actively search for theoretical and empirical interfaces with other disciplines. Without the ability to communicate across different interfaces, transformative or transdisciplinary cooperation cannot succeed. In addition, there must be a willingness to actively engage in dealing

with social problems. This cannot be done from the heights of the academic ivory tower. Nevertheless, for the sake of scientific rigour, it remains necessary to maintain a critical distance from the object of investigation.

What students can take away from this chapter:

- Knowledge about what is meant by transdisciplinary research, Mode 2, post-normal science, and real-world laboratory research
- An understanding of problem-oriented research on socio-ecological problems
- An understanding of the difficulties of knowledge integration in transdisciplinary research
- An understanding of the relationship between science and society

Recommended reading

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Nowotny, H., P. Scott & M. Gibbons, 2003: Introduction: "Mode 2" revisited: The new production of knowledge. *Compact presentation of the Mode 2 concept, which also includes a response to the criticisms of the original text by Gibbons et al. (1994).*

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