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Epistemic Complexity as a Philosophical Resource for Problem-Solving Strategies in the Context of Environmental Governance

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Contents

Introduction

This thesis is about the nature of complexity, about ways of knowing, states of not-knowing and most importantly, about fruitful ways of doing. This thesis discusses possible benefits of not being sure whether something is true – and more precisely, it discusses epistemic complexity as a philosophical resource for problem-solving strategies in the context of environmental governance.

In 2024, efforts to achieve environmental policy goals have shown to be insufficiently impactful. By means of discussing a number of complexity-related theories from Philosophy of Science (POS) and Science and Technology Studies (STS), this thesis aims at highlighting epistemic complexity as a potentially useful condition to propel impact in environmental governance. The reader will be encouraged to imagine new ways to deal with complex problems and gain meaningful insight into how a number of philosophical ideas can reveal a myriad of opportunities for practical change. The overall aim of this thesis is to make a small contribution to the discourse, by shining light on philosophies that not only cope with, but welcome uncertainty into their theories. The following is based on considering a perspective not entirely knowledge-dependent but driven by experimentation.

In 2023, "most Europeans think that within the EU it is the European Union, national governments and business and industry that are responsible for tackling climate change." Most Europeans also think that "climate change is a very serious problem at this moment" (European Commission. Directorate General for Climate Action., 2023) While efforts of issuing and implementing environmental policies are indeed pursued worldwide, practical steps to meet such goals remain insufficient (European Environment Agency, 2019).

The lack of practical action has been addressed globally and widely. Claims of *information deficit*[1] among policy makers and the general public are discussed in media and academia (Starkbaum et al., 2023) arguing for awareness campaigns and greater funds for scientific and educational institutions. Critics of capitalist systems condemn economic institutions for prioritising profits over conducts of sustainability. Critics of political systems condemn the perceived short-term perspectives of political actors who financially support industrial growth while obstructing the implementation of policies that secure the socio-economic livelihoods for their citizens. It appears that while these claims share a portion of relevance among them, no singular argument could yet offer a complete explanation, much less a solution for the observed lack of environmental action.

Arguably, one reason for this perceived lack of action lies in a general, suppositional dissensus about what “environmental crisis” encompasses. The vast variety of theory and practice that is associated with the term environmental crisis inhibits a clearly set definition. In some definitions, it describes the impact of the deterioration of the planet on human health and well-being. (World Health Organization, 2020) Other frames of reference center the definition around the natural world itself. (UNEP, 2022) Each definition may be equally legitimate and useful for science and policy contexts. However, when taking a philosophical perspective, it becomes clear that with each definition of a problem, different solutions may emerge, and thereby different expectations about what kind of action should be taken. Furthermore, this lack of a common definition may further lead to policies lacking a common goal as expert advice may be informed by different bodies of evidence and reasoning, from different professional communities. (Pielke, 2007) In spite of the awareness that there is no single definition for the environmental crisis, we may use it in its broad sense and refer to the Oxford English dictionary’s definition: “the sum of the environmental problems that we face today.” (Soanes & Stevenson, 2005)

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[1] The 'information deficit model' assumes that when a person's beliefs and attitudes, and consequently their behaviours, are not 'rational' or in line with what we would like, this is because of a lack of understanding caused by a lack of information. (Blake, 2020)

Since definitions of *complexity* are multiple and vary across disciplines, until defined otherwise within this thesis, the word "complex" by itself denotes the following: "consisting of many different and connected parts" (Soanes & Stevenson, 2005)

From the broad scientific disciplines of biology and physics, to economics, political science, history and the social sciences, to interdisciplinary and specialised fields such as ecological engineering and environmental psychology – the knowledge potentially relevant for environmental governance is immensely varied and abundantly generated and re-generated as time progresses. In many practical contexts, this can lead to *epistemic complexity*.

In this thesis, epistemic complexity shall denote the perceived incompatibility of a multitude of interconnected but sometimes conflicting sets of knowledge, often leading to a state in which one is unsure about whether something may reasonably be called *true*. The intricacies and possible ramifications of *epistemic complexity* will be discussed in detail in the coming chapters.

In a situation in which one is uncertain about whether something is true or not, it is sometimes assumed that collecting more information would diminish the uncertainty and lead to solution strategies. In other words, if one seeks to solve a certain problem, it is best to study said problem in as much detail as possible. This idea is for example reflected in the aforementioned *information deficit* model.) However, it is not by necessity that problem-studying and problem-solving are reciprocal activities, or that comprehensive problem-studying leads to successful problem-solving. On these grounds, this thesis will argue for problem-solving approaches that take the opposite perspective – and promote the idea that instead of attempting to fully understand and settle the definition of a given issue, one may take advantage of states of epistemic uncertainty. It will be argued that there are ways to explicitly utilise uncertainty and non-knowledge in environmental governance.

Since the Industrial Revolution in the mid 1800s, Western societies have experienced a sharp increase in wealth across social classes, while at the same point in history the harsh deterioration of the natural environment was initiated due to pollution from fossil fuel emissions. (Bond et al., 2007) By the 1950s, a different stage of Western development set off. As the global population, industry and consumerism grew to unprecedented heights, the impact that humans made on the Earth quickly grew as well. Today, this period is sometimes referred to as the Great Acceleration: “(...) the term was not intended for use in a precise mathematical sense but rather metaphorically to describe great changes in both [geological] Earth System indicators and related drivers in the socio-political-economic system post 1950.“ (Head et al., 2021, p. 3) Nevertheless, “the great acceleration has undoubtedly delivered major benefits, alleviating suffering and enhancing prosperity in many parts of the world (...) the share of the global population living in extreme poverty has decreased sharply – from 42% in 1981 to less than 10% in 2015. Yet the same developments have also caused widespread damage to ecosystems.” (European Environment Agency, 2019, p. 10)

In 1972, the United Nations (UN) held their first intergovernmental Conference on the Human Environment. (United Nations, 1973) This conference arguably marks the beginning of modern environmental governance. It established the United Nations Environment Programme (UNEP) and would further on shape intergovernmental codes of conduct in environmental policy efforts across countries and sectors. While previously the respective UN organisations for social development, nature preservation and economy worked mostly separately from each other, after the conference, forces were steadily joined between the three. (Selcer, 2018) This adoption of an inter-sectoral collaborative approach to environmental issues is since then referred to as Sustainable Development. Sustainable Development is arguably among the most significant concepts of the 21st century, perhaps most prominently reflected in the UN’s Agenda 2030, which includes the Sustainable Development Goals (SDGs) (Ross, 2023). Politically, this concept represents the idea that the well-being of the Earth’s ecosystem, global social development and a strong global economy are mutually dependent. While in 2023, countless initiatives and programmes to support the SDGs are in place – around the world, results are lacking. (European Environment Agency, 2019) “Globally, about 75% of the terrestrial environment and 40% of the marine environment are now severely altered. The Earth is experiencing exceptionally rapid loss of biodiversity, and more species are threatened with extinction now than at any point in human history. In order to halt and reverse these trends, interdisciplinary research and a multi-level policy approach is necessary, meaning that governments and policy makers as well as other stakeholders must tackle issues from multiple ends at once.” (European Environment Agency, 2019, p. 10)

In the context of the History and Philosophy of Science (HPS) and STS, a lot of attention has been drawn to the challenges of applying complex environmental knowledge in governance (Allenby & Sarewitz, 2011; Funtowicz & Ravetz, 1993; 1994; Pielke, 2007). Pointing to the difficulties of dealing with complex knowledge, it has been argued that knowledge can present as provisional, imperfect, uncertain and partial. Some of the rigidity in environmental governance may therefore be explained via the given complex attributes of its underlying knowledge system.

This thesis will however investigate the opportunities that can arise from dealing with epistemically complex knowledge systems. Since, as long as one is uncertain about the specifics of what they have – or do not have at hand – they are not confined to any one action, but may explore a myriad of options.

This investigation will encompass:

1. The concept of *Post-Normal Science* (PNS) (S. O. Funtowicz & Ravetz, 1993; Strand, 2017) which has its roots in Philosophy of Science and the science-policy-intersection. At its core lies the idea that PNS should be applied when "facts [are] uncertain, values in dispute, stakes high and decisions urgent".
2. The *Precautionary Principle* is a concept originally from law that has been employed to help decision makers in assessing a policy's risk of harm to persons or the environment. It can be summarised by the motto “better safe than sorry”. Numerous European Governance Institutions suggest to regularly apply the precautionary principle for governance decisions regarding the environment, public health, and other domains. (European Parliament, 2016; UNESCO, 2005)

3. Notions of *Care* (De La Bellacasa, 2011; Gilligan, 1982; Haraway, 2016; Latour, 1994; Mol et al., 2010; Norlock, 2019) which may become productive for both knowledge generation and problem-solving in multiple ways and from various perspectives but are at their core informed by the human act of taking care, exercising reflexive learning rather than working towards a predefined outcome.
4. The notion of *Tinkering* (Bevan et al., 2014; Marcus et al., 2021; Mol et al., 2010; Rachelle, 2012) which puts emphasis on the benefits of experimentation, assuming a stance not fixed to a certain problem-solving strategy but an explorative approach by tinkering with a given problem.

In chapter 1, instances of complexity at the intersection of environmental science and policy will be reviewed and traced back to the concept of *wicked problems* (Rittel & Webber, 1973). Discussing the specific attributes of wickedness will further enable an in depth understanding of complexity for the following chapters. It will further encompass a discussion of the most recent SOER report – The European Environment, State and Outlook 2020 (2019), by the European Environment Agency (EEA).

Chapter 2 will attempt to show that epistemic complexity can be regarded as a foundational condition of scientific research and problem-solving. By discussing problem structures from a philosophical perspective, borrowing insights from computer modelling, this chapter will search for some of the philosophical root causes for epistemic complexity, as well as some of the reasons why epistemic complexity can be so difficult to deal with.

Chapter 3 will review the mentioned number of relevant selected concepts for dealing with epistemic complexity, discussing literature about the conceptual framework of *PNS*, the *precautionary principle* and the concepts of *care* and *tinkering*.

Chapter 4 will discuss the relationship between the results from each chapter in the light of an EEA report titled "Governance in complexity: sustainability governance under highly uncertain and complex conditions." (European Environment Agency., 2024) to pursue the main question: What can conditions of epistemic complexity offer for problem-solving endeavours in the interface of environmental science and policy?

Chapter 1

At least since the 1970s, scientists and other experts have researched complexity at the intersection of science and policy. When taking a closer look, it may become apparent that complexity can be identified at many points and in many aspects of this field.

Intuitively, one may expect a problem of a simple structure to be easier to solve than a problem of a complex structure. Philosophically however, complexity does not necessarily imply difficulty or complication. This thesis shall argue that certain conditions of complexity can indeed function as favourable for the problem solver.

In the process of framing problems that show to be as large and varied as the environmental crisis, their structures may turn out to be highly complex and could thereby be expected to be highly difficult – or even impossible to resolve. Problems that show such degrees of complexity are sometimes referred to as *wicked problems*, as for example by the European Environment Agency in reference to the environmental crisis. By discussing a recent report from one of the EEA's most prominent policy advisory works, section 1.1 of this chapter shall give insight into how environmental governance institutions deal with instances of complexity and wickedness. As an important environmental advisory institution to the European Union, the EEA is productive at the intersection of environmental science and policy on a significant scope.

It will be concluded that the environmental crisis indeed shows high degrees of complexity and is as such deemed a wicked problem by the EEA. Ways of dealing with the uncertainties that thereby emerge are however described as insufficient within EU governance institutions.

Section 1.2 aims to present an in-depth analysis of the research paper that has coined the term "wicked problem", written by the urban design theorists Horst Rittel and Melvin Webber. It will be concluded that the environmental crisis may accurately be described as a wicked problem. Furthermore, it will be argued that the underlying principle of wickedness is an element of epistemic complexity, leading to states of uncertainty for the problem solver.

Section 1.3 of this chapter will assume a general problem formula given by Rittel and Webber and with it attempt to re-frame the environmental crisis as non-wicked – however with only partial success. Examining the root causes for not fully succeeding will be the main focus of chapter 2, where epistemic complexity will be philosophically examined in terms of its significance for science and problem-solving.

1.1 SOER 2020

The following shall present an aggregated discussion of the European Environmental Agency's 2020 SOER Report. It will review its contents with a particular focus on systems thinking and complex knowledge. It shall also address the EEA's approach to handling complex knowledge with respect to resolving environmental issues and achieving policy goals.

The SOER report is published approximately every five years by the EEA and is among the most cited policy advisory documents. It is the primary means of communication from the EEA to the European Commission with guiding knowledge for environmental governance. The European Commission "is alone responsible for drawing up proposals for new European legislation (...) [and promoting] the general interest of the EU by proposing and enforcing legislation as well as by implementing policies (...)." (*European Commission – What It Does | European Union*, n.d.)

The EEA is a so-called decentralised agency of the European Union, which implies that the EEA does not carry official responsibilities for EU policy as it is explicitly "distinct from the EU institutions". (European Parliament & Council of Europe, 2009) However, the EEA has a mandate to provide scientific information so as to make EU environment and sustainability policies well-informed. Indeed, the SOER series may be described as the policy advisory publication with the most authority for environmental issues in Europe. The latest SOER report presents an assessment of the current state of the natural environment and environmental governance in the EU and gives an outlook for subsequent years, especially towards 2030. The report is written in contexts of multiple European and global policy goals, such as the UN's Agenda 2030, the European Green Deal and the EEA's own Environment Action Programme (EAP).

The EEA states that the EU's environmental policies are mainly guided by three thematic priorities: "to protect, conserve and enhance the EU's natural capital", "to turn the EU into a resource-efficient, green and competitive low-carbon economy" and "to safeguard the EU's citizens from environment-related pressures and risks to their health and well-being." (European Environment Agency, 2019, p. 56)

The latest SOER report consists of four parts and 18 chapters, each focusing on a different aspect of the European environment and governance. Part 1, "Setting The Scene" contains an overview of the (then) current state of the natural environment in Europe, followed by an assessment of the socio-economic context that Europe stands in with the rest of the world and how these relations affect the environmental state in Europe. It closes with a description of the relevant European environmental policies and goals. Part 2, "Environment And Climate Trends", makes up the main body of the report. It assesses the progress made towards various policy goals, focusing mainly on the time frame between 2010 and 2020, whereas 10 specific environmental themes are analysed: Biodiversity and Nature, Freshwater, Land and Soil, Marine Environment, Climate Change, Air Pollution, Waste and Resources in a Circular Economy, Chemical Pollution, Environmental Noise and Industrial Pollution. The final two sections provide an integrated picture of the mentioned themes in relation to the objectives of the 7th EAP.[2] Part 3 presents a theoretical discussion, consisting of three chapters, titled "Sustainability Through a System Lens", "Understanding Sustainability Challenges", and "Responding to Sustainability Challenges". This thesis mainly references part 3 of the report, as it provides insights into how governance institutions handle complex knowledge systems. Part 4 of the 2020 SOER report gives a final conclusion as well as an outlook, titled "Where Do We Go From Here?"

The report makes light of some of the issues that policy makers perceive as problematic in applying environmental knowledge for governance. It also discusses some of the perceived difficulties in shifting from traditional governance structures to structures that respond to the diverse and varied necessities in working to achieve sustainability goals.

Some of the key points are the following:

[2] The 7th EAP was in effect from 2013 to 2020 and contained various environmental goals towards a green and sustainable EU. As of 2024, the 8th is in effect (2022-2030). (7th Environment Action Programme, 2013)

- “Where there has been progress on reducing emissions and impacts on human health, the improvements are insufficient to meet the long-term objectives to 2050.“ (p. 415)

- “Policies and decisions that take a systemic view of sustainability issues based on science-informed analysis have a better chance of long-term success.“ (p. 345)

- “Sustainability transitions will require a detailed understanding of the systems driving environmental challenges and potential pathways to sustainability and their implications across society.“ (p. 415)

- “New and more inclusive modes of knowledge production are needed, building on big data and foresight.“ (p. 415)

The SOER report describes the environmental crisis as a problem structure that consists of multiple interrelated parts (...) [allowing for] the observation of natural and social phenomena at an appropriate scale, by zooming in and out, and looking for underlying structures and patterns. (p. 344) Achieving environmental goals would therefore require to adopt a systemic view on the issue. It is argued that from a knowledge-theoretical perspective, adopting a systemic view that enables system thinking, would help policy makers to approach and reflect “on the complex or wicked problems facing Europe”. (p. 344)

It describes the crisis as a problem that consists of multiple interrelated parts, and concurrently describes it as complex. This is congruent with the above mentioned broad definition of complex: “consisting of many different and connected parts” (Soanes & Stevenson, 2005) The report links the attributes *interrelated*, *complex*, and *systemic* in its description of the environmental crisis as a specific problem for EU governance.

Insofar, the terms “interrelated” and “complex” are used interchangeably in the SOER report. As can be inferred from the previous (and following) quotes, the term “complex” often appears as a adjective that signals a negative, problematic quality, whereas “systemic”, “system thinking” and “systemic view” tend to appear as resolving and positive. To an extent, interrelatedness and complexity on one side are described as counterparts to systemic attributes on the other side. The EEA presents system thinking as a favourable strategy to tackle issues of complex kinds, as is stated in the report (see key points on the previous page) stated that policies and decisions that take a systemic view of sustainability issues based on science-informed analysis have a better chance of long-term success.

The most important factor to this point is identified to be the interlinkedness of economic activities and lifestyles with the natural world. Resources, pollution, jobs and earnings as well as infrastructure and policies, knowledge and skills are “inextricably” linked and tied to one another in complex ways: “Decades of research in academic fields such as complexity science, ecology, sustainability science, evolutionary economics or innovation studies have produced a variety of relevant systems approaches, providing insights into the environment, climate and sustainability challenges and possible responses.” (p. 344)

As the need to apply a “systems lens” in environmental governance is continuously emphasised, a portion of the report is dedicated to the challenges of dealing with complex knowledge systems, re-stating the need for policy makers to respond specifically to the complex attributes of environmental knowledge. Accordingly, the EEA recognises the importance of facilitating scientific knowledge for policy in a way that provides insights about the systems that drive environmental pressures. “Generating, sharing and using relevant evidence to the full may require changes in the knowledge system linking science with policy and action, including developing new skills and institutional structures.” (p. 17) These challenges are however not addressed sufficiently: “More than ever, ensuring that relevant and credible knowledge is actually used by decision-makers is a key challenge.” (p. 422) In light of this, one reason for the rigidity in environmental governance becomes apparent.

The suggested need for developing new “institutional structures” is among the bold statements that the SOER report contains. As an institution with as much authority as the EEA, making such statements could in itself be regarded as a practical step towards various policy goals. As such, the EEA does explicitly point to discrepancies between the EU’s general recognition of the importance for systems thinking approaches, but the lack of structural possibilities within the EU to actually implement them.

The varied knowledge that is generated by environmental research is however recognised as being both favourable and unfavourable. Here the report specifically addresses instances of *epistemic complexity*: “The growing body of research into sustainability transitions and transformations has its roots in diverse research fields. Ecology, evolutionary economics, innovation theory and political economy each focus on different kinds of change processes and scales of activity. Yet, this diversity is increasingly coalescing into a broadly shared understanding of sustainability challenges, which emphasises the barriers to transforming complex systems and the role of drivers of change at the macro and micro levels in enabling the emergence of new ways of living, working and thinking.” (p. 380)

As was mentioned in the introduction, the knowledge potentially relevant for environmental governance is generated by scientists and experts stemming from various fields. Environmental knowledge is produced interdisciplinarily, and may therefore be referred to as a *complex knowledge system*. In practical contexts, this can lead to states of uncertainty, which may pertain to at least two different implications. Firstly, one could find themselves in a state of uncertainty about which set of information should be deemed *true*. Secondly, as a result, one could perceive uncertainty about how to proceed in a problem-solving endeavour. In other words, one may be unsure about what to do next when epistemic complexity emerges during the problem-solving process.

As a way to mitigate epistemic complexity, the EEA recognises the importance of integrating the complex environmental knowledge system and achieving a shared understanding of sustainability challenges. The current EU policy structures are however deemed not sufficiently prepared to do so.

The 2020 SOER report makes a case for the importance of responding to the challenges the EU is facing by adopting a systems thinking approach that shall integrate complex knowledge. It is suggested that governance institutions take on a multi-level approach to tackling environmental issues, whereas governments should enable people from all parts of society to partake. All of this should ideally be grounded on scientific knowledge, which is deemed valuable in its complex character and is in itself pointing to the necessity of dealing with complex issues from multiple ends. However, there remain various uncertainties about how to realise this necessity.

Concludingly, it may be established that the environmental crisis is a problem of high complexity, recognised as such by governance institutions such as the EEA and EU. Attempts of resolving it have not yet had the success that policy makers set out. In part, this can be explained in terms of the uncertainties in dealing with complex environmental challenges.

1.2 Wicked Problems

Horst W. J. Rittel and Melvin M. Webber wrote “Dilemmas in a General Theory of Urban Planning” in 1973. Since its publication, this paper has generated waves of responses throughout academia. In 2024, *wicked problems are* still a popular concept, especially in the social sciences, where problems that are perceived as highly difficult to resolve are often described to be wicked.

Rittel and Webber distinguish two main categories of problems, which vary in their degree of complexity: *wicked* problems and *tame* problems. A *wicked problem* is a problem that is complex to a degree where ordinary strategies for solving it do not apply. A *tame problem* on the other hand shows a lower degree of complexity and may be solved more easily.

Rittel and Webber first define how to imagine the structure of any problem, may it be wicked or tame. Any problem is generally to be defined as a circumstance showing “(...) discrepancies between the state of affairs as it is and the state as it ought to be”. (Rittel & Webber, 1973, p. 165) Therefore accordingly, in order to frame a problem, one may judge upon and formulate the present circumstance first, *the state of affairs as it is* – and secondly the desired outcome, *the state as it ought to be*. Unfortunately, the literature on wicked problems and problem-solving in general does not always use a clearly distinct vocabulary.

It is useful to be aware of such distinctions and most importantly of the difference between a *desired outcome* and a *solution*. One might assume that since these terms themselves bear ambiguity, they may be used interchangeably. However, for the purposes of understanding problem-solving strategies as well as the specific purposes of this thesis, a clear distinction is necessary. Within this thesis, a solution designates a step taken towards a desired outcome. A solution may act as a tool to resolve discrepancies between the “state as it is” and the “state as it ought to be”, which ideally makes it possible for a desired outcome to become realised. One may imagine the interrelation of these two terms in a causal and linear order. Beginning with the state of affairs as it is, one may propose a solution. This solution may be applied as an act of problem-solving. If the attempt of solution is successful, the desired outcome realises itself, thereby evolving into the state of affairs as it ought to be.

Recognizing this subtle difference enables a clearer understanding of the topic at hand, and can also be useful, for example, when dealing with environmental policies. It can help to differentiate between the recognition of a desired outcome, such as the *mitigation of global warming through reduced CO2 emissions*, and a solution that may lead to this desired outcome, such as an *enforced policy that puts a limit on CO2 emissions*.

In the following, the original concept of *wickedness* shall be re-visited and re-analyzed. Based on this analysis, it shall be discussed if deeming the environmental crisis a *wicked problem* is meaningful and useful.

According to Rittel and Webber, tame problems appear in many instances of the natural sciences. They are usually to be found in contexts where the framework in which the problem as well as the solution lie, are given or at least apparent. “The problems that scientists and engineers have usually focused upon are mostly "tame" or "benign" ones. As an example, consider a problem of mathematics, such as solving an equation (...) or that of the chessplayer attempting to accomplish checkmate in five moves. For each, the mission is clear.” (p. 160) In contrast, when dealing with *wicked* problems, the mission may not be as clear, as they tend to rely on value judgements. This should not suggest that all problems of the natural sciences are easily solved compared to the social sciences. Pointing to this contrast should make light of the differences in the nature of problem structures and logical approaches that are typically applied for the two domains. The problem-solving strategies that apply to problems of the natural sciences tend to be clear and linear, as they exist within (more or less) set frameworks and logical rules, such as within the mentioned games of chess and mathematics. The same problem-solving strategies rarely turn out to be useful for problems that encompass multiple and varying domains, as within governance settings, or the social sciences as such, as frameworks and rules differ greatly. “We shall want to suggest that the social professions were misled somewhere along the line into assuming they could be applied scientists – that they could solve problems in the ways scientists can solve their sorts of problems. The error has been a serious one.” (p. 160)

“Wicked problems (...) include nearly all public policy issues – whether the question concerns the location of a freeway, the adjustment of a tax rate, the modification of school curricula, or the confrontation of crime.“ (p. 160) In contrast to tame problems in natural science disciplines, wicked problems in the social sciences are always situated within one or multiple open systems, making them to various degrees entangled with other problem structures. There is no linear chain to be traced from a wicked-problem definition to a desired outcome, but the wicked problem shows to exist within a network-like structure with no one path for it to be solved. This may frequently be the case in policy and governmental planning.

For instance, Rittel and Webber ask about how one could meaningfully define a poverty issue in a given city, quickly making it clear that problems of this kind show complications in every aspect, from formulation to solution. “Does poverty mean low income? Yes, in part. But what are the determinants of low income? Is it deficiency of the national and regional economies, or is it deficiencies of cognitive and occupational skills within the labour force? If the latter, the problem statement and the problem "solution" must encompass the educational processes. But, then, where within the educational system does the real problem lie? What then might it mean to "improve the educational system"? (...) – and so on." (p. 161)

For the case of the environmental crisis, the described difficulties seem to apply similarly. While it may not be especially difficult to formulate one version of the environmental crisis as defining a discrepancy between the state of affairs as it is and the state of affairs as it ought to be. But to give an exhaustive formulation that encompasses all its features and aspects, has, as all lack of evidence suggests, not been found yet. Such complications do point to the environmental crisis being a wicked problem, however in order to fully decide if a problem should be called wicked, Rittel and Webber provide a list of ten features.

1. *There is no definitive formulation of a wicked problem*. As discussed, wicked problems are ill-defined as they are. However, to resolve existing discrepancies, one must still define the wicked problem to a minimum degree in order to be able to make meaningful problem-solving attempts. If one manages to clearly define both the present unwanted situation as well as the desired outcome, the problem at hand becomes *tame* per definition, and more problem-solving strategies become applicable. On the other hand, if neither the unwanted present situation nor the desired outcome can be defined at all, there is no action to be taken that could be judged upon as resolving or effective.". (p. 160)

2. *Wicked problems have no stopping rule*. For problems that exist in closed systems, there is a limited set of outcomes for every solving attempt. Wicked problems however are marked by the unlimitedness of outcomes per attempt. "No stopping rule" refers to the characteristic of wicked problems being entangled into one or multiple open systems and the openness of such systems that brings with them an inability to reasonably declare an end point to the solving of a wicked problem — "because there are no ends to the causal chains that link interacting open systems, (...) [one] can always try to do better." (p. 162)

3. *Solutions to wicked problems are not true-or-false, but good-or-bad.* “Normally, many parties are equally equipped, interested, and/or entitled to judge the solutions, although none has the power to set formal decision rules to determine correctness. Their judgments are likely to differ widely to accord to their group or personal interests, their special value-sets, and their ideological predilections. Their assessments of proposed solutions are expressed as "good" or "bad" or, more likely, as "better or worse" or "satisfying" or "good enough." (p. 163)

4. *There is no immediate and no ultimate test of a solution to a wicked problem.* Since wicked problems are entangled in complex ways, any practically attempted solution will most likely affect the rest of the open system(s) too, generating “waves of consequences” over a period of time. Due to the openness of the system, however, Rittel and Webber point out that this may even be an “unbounded period of time” (p. 163).

5. *Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan*. This fifth feature shows how wicked problems, in addition to being ill-defined in their formulation, are also ill-definable in their possible solutions (regardless if the judgements are expressed as true or false, or good or bad). “Chess has a finite set of rules, accounting for all situations that can occur. In mathematics, the tool chest of operations is also explicit”. It is argued that in such instances, practical, and more importantly “feasible” plans of action must be informed by “realistic judgement” and the capability and willingness of those in decision-making positions to try out new and unusual ideas. (p. 164)

6. *Every wicked problem is essentially unique.* “Despite seeming similarities among wicked problems, one can never be certain that the particulars of a problem do not override its commonalities with other problems already dealt with.” (p. 165) While the term “unique” signals exactness and definitiveness, a wicked problem's uniqueness lies, as Rittel and Webber point out, in the circumstance that one can not be certain about seeming similarities between two wicked problems.

7. *Every wicked problem can be considered to be a symptom of another problem.* For a wicked problem, there is essentially no right or wrong starting point to solve it. Neither is there a specific symptom of it that can be considered its "natural level" (...) "the level at which a problem is settled depends upon the self-confidence of the analyst and cannot be decided on logical grounds. There is nothing like a natural level of a wicked problem." (p. 165)

8. *The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution.* "People choose those explanations which are most plausible to them. Somewhat but not much exaggerated, you might say that everybody picks that explanation of a discrepancy which fits his intentions best and which conforms to the action-prospects that are available to him. The analyst's "world view" is the strongest determining factor in explaining a discrepancy and, therefore, in resolving a wicked problem." (p. 166)

9. *The planner has no right to be wrong*. The ninth point refers back to the qualitative nature of solutions to wicked problems and the responsibilities that the ones trying to find them carry. As there is no right or wrong action that could objectively be judged upon as such, the aim should merely be to "improve some characteristics of the world where people live." (p. 167)

10. *Every solution to a wicked problem is a* one-shot operation *because there is no opportunity to learn by trial-and-error, every attempt counts significantly.* While for closed systems such as mathematics or chess, one may attempt to solve a problem several times, without altering the system. With wicked problems however, every try is said to have consequences that alter the system. These leave "traces" that can not be (easily) undone.

The discussed list of features does seem to apply to the environmental crisis: since experts have differing views about causes and effects of the environmental crisis, there is no *definitive formulation* to it. There is *no stopping rule* to it, as there is no measurable point defined at which experts would regard the crisis as over — the state of the environment can always be improved further. Similarly, environmental efforts may not be judged upon as *true or false* but only *good or bad*, considering that "crisis" is in itself a term of value judgement. Due to the global scope of the environmental crisis, *testing out an attempt at a solution can legitimately be deemed impossible*, as no complete set of variables to consider is defined. Attempts of solution are essentially *one-shot operations* as every try has consequences that alter the system and can not be (easily) undone. There is neither a *pre-established set of problem-solving strategies* that a potential problem-solver could refer to. This is among other reasons due to the environmental crisis being a *unique problem*, meaning one cannot confidently equate it to other wicked problems. The environmental crisis can further not naturally be settled as one distinct entity – it is always possible to describe it as *a symptom of another wicked problem*. Finally, explaining the environmental crisis will always strongly depend on the *analyst's world view* and with this comes responsibility. The responsible person does in this case not have a *right to be wrong*.

In all of the above presented features, one shared underlying element is indetermination or openness in both defining the problem as well as identifying solutions.

Whereas the closed problem structure of a tame problem allows for a limited number of possible definitions and solutions, the openness of a wicked problem allows for a potentially infinite number of definitions and solutions. It may be inferred that it is this indetermination or openness that causes the wicked problem solver to find themselves in states of uncertainty about how to proceed. In a circumstance where such multitudes emerge, one may state that epistemic complexity has ensued.

As defined above, epistemic complexity denotes the perceived incompatibility of a multitude of interconnected and sometimes conflicting sets of *knowledge*, often leading to a state in which one is unsure about whether something may reasonably be called *true*.

As for the process of wicked problem-solving, one may establish the following: When a problem structure shows epistemic complexity, a problem solver may find the incompatibility of a multitude of interconnected and sometimes conflicting sets of *problem definitions (and solutions)* leading to a state in which they are unsure about whether something may reasonably be called *applicable*.

It shall therefore be argued that the openness of the wicked problem structure causes epistemic complexity to be the essential feature of wickedness.

1.3 Taming Wickedness

If it is the element of openness that causes epistemic complexity, it follows that epistemic complexity may be combated by attempting to close the problem structure. Rittel and Webber do point to possible ways of doing so, such as under feature seven: “the level at which a problem is settled depends upon the self-confidence of the analyst and cannot be decided on logical grounds. There is nothing like a natural level of a wicked problem.” (p. 165) Additionally, under feature eight, it is proposed that “the analyst's "world view" is the strongest determining factor in explaining a discrepancy and, therefore, in resolving a wicked problem.“ (p. 166)

In this way, a problem solver may find it necessary to make choices informed by subjectiveness in order to allow themselves to define the problem and further any applicable solution strategies. Naturally however, as for cases of the science policy intersection, the problem solver would want to guide their decision alongside scientifically robust information and indubitably not simply apply their personal opinion onto the problem.

The following shall consider how a problem solver in the science policy intersection could frame the environmental crisis in a way that leaves it possible for them to identify favourable solution strategies.

One may state that there is a discrepancy between the state of the global environment as it is and the state of the global environment as it ought to be. For comprehensive reasons, the re-formulation will begin by defining the second part of the formula, *the state of affairs as it ought to be*.

As all lack of evidence suggests, there is no policy that establishes a universally agreed upon environmental state of affairs as it ought to be. Most of the so-called environmental policies are concerned with either *global warming* or *climate change*. These however are issues that, on the conceptual level, differ greatly from the environmental crisis. As it is, climate change and global warming can be effectively and quite simply expressed by physical and measurable values, specifically by the rise of the global average temperature on Earth. Contrary to the *environmental crisis*, these concepts do not necessarily contain the causes and reasons for the state of the environment, such as pollution, biodiversity loss, overpopulation, consumerism and the like. Thus, global warming and climate change policies do not tend to respond sufficiently to instances of complexity – as established in the SOER report.

Policies such as the Paris Agreement should not be regarded as policies about the environmental crisis, but only about global warming or climate change, as the Paris Agreement is neither discussing instances of complexity, nor does it provide practical solutions for global warming. One may describe it as a policy document that gives a guideline as to the general direction in which the UN member states are headed – less by proposing solutions, more by defining the desired outcome.

The goal of the Paris Agreement is set as "holding the increase in the global average temperature to well below 2°C above pre-industrial levels".[3] (The Paris Agreement, 2016) It was ratified by 194 UN-member states, and the EU. As of 2024, there is no equivalent official policy that addresses environmental issues on a wider scope. While not addressing the full scope of the environmental crisis, the Paris Agreement does closely fit the description of "universally accepted", which provides an idea of the state as it *ought to be*.

[3] It is however not establishing a certain point in time at which this goal is to be realised. Whereas the year 2050 as a time marker for the limiting of global warming is not mentioned in the official document of the Paris Agreement, this year is by various media as well as various environmental programs established as a target to reach net-zero, meaning to cut greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed by oceans, forests or emission-reducing technology.

If one accepts the previous remarks, one may however take the freedom to regard *the state as it ought to be* as a state of the global ecosystem that is characterised by a climate no warmer than 2°C on average compared to pre-industrial times – questions of problems like pollution and consumerism not being addressed.

Thus, the problem formulation of the environmental crisis may be expressed as: “The discrepancy between the state of affairs as it is and holding the increase in the global average temperature to well below 2°C above pre-industrial levels.” – so far, remaining incomplete.

Regarding the first part of the problem formula, it turns out that choosing the components necessary for defining the environmental “state of affairs as it is" brings challenges related to both epistemic complexity and temporal change, which, in the following chapter, will be described as *radical openness* and *contextuality*.

By means of an in depth discussion of the difficulties of giving an exhaustive description of the environmental state of affairs as it is, chapter 2 will attempt to show how epistemic complexity must not necessarily be regarded a hindrance for problem-solving, but could even become a useful resource. It shall also be proposed that epistemic complexity is a fundamental condition of the scientific pursuit – thereby making it foundational to the science policy intersection.

Chapter 2

By means of a philosophical discussion, borrowing insights from systems theory and complex systems science, chapter 2 will attempt to show that epistemic complexity can be regarded as a fundamental condition of scientific research and furthermore problem-solving. This leads to the understanding that the absence of epistemic complexity would bear no benefits for problem-solving endeavours or scientific knowledge generation overall.

The following section shall explore the greater epistemic implications of complexity for scientific research.

First and foremost, "environmental crisis" is a term. The reader of this term supposedly has an understanding of what *environmental crisis* signifies, however giving an exhaustive description of everything the term encompasses will likely turn out to be highly challenging. As established, the environmental crisis consists of many interrelated parts, each in themselves definable by different disciplinary perspectives. Additionally, the natural environment is constantly changing as time progresses. Because of this, choosing the components necessary for defining the environmental *state of affairs as it is* brings challenges of various kinds. Although there may be a lot of relevant facts that come to mind when attempting to describe the current state of affairs, it can be difficult to find any academic or otherwise established references declaring what exactly to include and exclude for a definition of the present environmental situation.

As the *environmental crisis* as a concept is theoretically and practically interlinked with other concepts, such as climate change, global warming and sustainability, the environmental studies as a research objective are therefore interdisciplinarily organised.

They include natural sciences as well as social sciences and the humanities, whereas each contains sub-disciplines with again each their own particular ways of knowing. This may not least be due to the epistemological advantages of interdisciplinary research methodologies that fields such as environmental studies employ. "The fundamental reason people conduct interdisciplinary studies is that a disciplinary approach fails or is insufficient in creating an understanding of the question in focus.“ (Öberg, 2010, p. 17)

However, the distinct disciplines sometimes contain fundamental differences in epistemological framework and methodology. Across these disciplines, frictions might occur as an expression of epistemic complexity. As such, each concept is partly sharing, partly varying in their objectives and ways of knowing. As such, epistemic complexity may also occur as uncertainty about how to judge upon the validity of scientific methodologies or uncertainties about how to meaningfully interpret results. Although instances of epistemic complexity can arise in any research setting, it seems reasonable to expect an increased possibility for interdisciplinary research fields.

Therefore, in an attempt to give a full description of the *environmental crisis*, one may find themselves negotiating over which sets of knowledge from which disciplines they shall include in their description. One may reasonably include conservation biology, environmental engineering, environmental economics, atmospheric science, oceanography, environmental sociology as well as political theory and history, and many others. Thus, assembling all relevant information for an exhaustive description of the environmental crisis poses a highly demanding task for any one person.

A similar difficulty, however, may also occur with much simpler terms, such as *tree*. The reader may have a much clearer understanding of *tree* than of *environmental crisis*, since a tree is not primarily an abstract concept, but a thing one can point to. But to give an exhaustive description of any one tree will likely turn out to be just as difficult. From studying the growth patterns of its roots to the process of photosynthesis, there is a potentially unlimited amount of knowledge to be gathered from a tree – not least because its attributes change over time. To this point, one might say that the difficulties of giving an exhaustive description of a tree are due to trees being *complex systems*. This statement is worth exploring. The following aims at discussing the philosophical intricacies of complex systems and how conditions of epistemic complexity may emerge in such systems.

2.1 Complex Systems

Both with respect to the notion of complexity and that of complex systems, definitions vary. As for disciplines that formalise complex systems and apply complexity theory in their research, there are however observable and describable features of complex systems that have been significant. Such disciplines include, among others, system theory, engineering and computer science and particularly modelling. For the purpose of understanding how conditions of complexity emerge in complex systems. Chu et al., (2003) propose two essential features of complexity: "(...) whatever definition one might one day agree on, contextuality and radical openness are essential features of complexity." (p. 19) This following section discusses the concepts of contextuality and radical openness as presented by Chu et al. The tree will continue to serve as an example case.

For a scientist studying any given tree, a productive first step may be to identify the tree as such – thereby establishing what shall be considered the tree, and what shall be considered not the tree. The rigorous demarcation of a real-world tree from its surrounding is however not a simple task. Trees exist in continuous interrelations with other systems, themselves definable as for example the atmosphere, the soil or the local insect population. These systems do in the natural world interact so closely with trees, that the existence of one can directly depend on the existence of others. For example, a tree constantly exchanges matter with its surrounding soil, such as pulling nutrients through its roots, but also by dropping leafs that again rot into the soil, making it difficult to determine where the tree ends and the soil begins. This phenomenon of interrelation in nature is one of the primary interests in the discipline of ecology. (Jaiswal, 2023) Interrelation can however pose a problem for a scientist. In order to identify and study any system, one must be able to delineate between what is the system and what is not the system. In modelling, this process is referred to as choosing *system boundaries*. "It is the skill of a modeller to find these boundaries, because they define the domain of successful and efficient modelling." (Chu et al., 2003. p. 19)

For example, if a scientist is to study the medicinal properties of a birch tree, they might not take into account any statistics about the tree's pollen expulsion, given they do not suspect any relevant causal relationships. In this way, a scientist is expected to purposefully select a set of attributes as informed by their methodological training, which they deem the chosen set of attributes relevant for answering their research question. In an instance where a scientist decides to deem the pollen expulsion irrelevant for their research question, the scientist is drawing system boundaries around their tree. By doing so, they make a partition between the system tree that is of interest and relevant for studying the medicinal properties of the birch tree – and everything that is not. Generally, "every definition of a system partitions the world into two parts, namely the system and its ambiance." (p. 22)

In some instances however, there may be no specific research question for a scientist to refer back to. Whenever one's aim is to fully describe a given thing or concept, choosing the system boundaries may become more difficult. Hence, if one's research interest is directed towards the tree in all of its entirety, then all of its surrounding systems, including the atmosphere, the soil, the local insect population and many more become potentially relevant. Particularly in computer modelling this is a much discussed issue.

According to Chu et al., if for this reason a scientist cannot easily construct a closed system by setting its boundaries, the system shows the attribute of *radical openness.* "Intuitively, one might try to simply internalise more and more of the ambiance in to their system to have it include as much relevant information as possible, however this will not make it any less radically open but "will create another radically open system; this larger system will contain the old system and parts of its ambiance." (p. 25)

A skilled modeller however may reduce radical openness by putting so-called sources and sinks onto the system boundaries, which allows them to clearly define boundaries but with the possibility of accounting for informational input and output from the ambiance. "The radical openness is reducible if the ambiance interaction can, for specific modelling purposes (especially on specific spatial and temporal scales) be internalised (sinks and sources) by some choice of system boundaries.” (p. 24)

Once all information inside the chosen system boundaries was successfully obtained, one may definitively give an exhaustive description of their subject, thereby inhibiting the feature of radical openness. This partitioning may also help to inhibit contextuality by allowing a scientist to judge upon the specific significance of the obtained information, as according to the system boundaries. Without setting boundaries to their research, a scientist may be unable to judge upon the relevance of any information they obtain.

“These practices artificially reduce uncertainties and variations, for example by the ways in which averaging, standardisation, and aggregation are performed. The fact that this is necessary and justified by the need to generate knowledge does not alter the point that it imposes man-made intellectual closure around entities which are more open ended than the resulting models suggest.“ (Wynne, 1992, p. 113)

For the case of describing the entirety of a tree, reducing its radical openness might be achievable by temporally and spatially scaling the impact of its ambiance by introducing the according sources and sinks to the model. It is questionable however if this is possible in an attempt to model the entirety of the environmental state of affairs as it is.

One may explain the reasons for this by means of radical openness or wickedness, as was previously discussed. In wickedness, elements of radical openness might be most obviously discerned in the proposition that every wicked problem “can be considered to be a symptom of another problem” where it was laid out that there is no natural level or starting point from which the environmental crisis could be defined or solved.

On these accounts, one may justifiably deem the environmental crisis a system of *radical openness*, thereby exhibiting the first feature for complexity as defined by Chu et al. The second feature, *contextuality*, appears to apply as well, as shall be shown in the following.

“We will call a system contextual if it includes one or more elements that also occur in a different system(s) or if it is itself a shared element between more than one system. In this other system(s) the shared elements take part in causal processes different from those included in the original system.“ (Chu et al., 2003, p. 25) This attribute is evident in various instances of the environmental crisis, and indeed much discussed in research but also in policy contexts. One of the perhaps most notable discourses being potential synergies and trade-offs across the 17 Sustainable Development Goals (SDGs).

“One and the same natural system may be studied and modelled using a number of different approaches. Accordingly the models will focus on different aspects of the system and will be motivated by various interests, research programmes and problem definitions. One might, for example, model Lake Victoria as an economical resource, ecological system, as a part of a larger ecological system and so on. There is thus a family of overlapping possible and actually realised models. This is the source for what we will call contextuality.“ (p. 25)

One example for a direct trade-off between two SDGs is the circumstance that alongside SDG 7, *affordable and clean energy*, the use of renewable energy is increasingly promoted and facilitated. Yet, in order to construct technologies such as solar power panels, critical materials, such as lithium and gallium, are required. Mining these materials can harm or even destroy the livelihoods of both animals and humans. This poses a trade-off to SDG 15, *life on land*. (Van Der Ent et al., 2021)

In this way, when attempting to describe the environmental crisis as a system, some elements can be observed to simultaneously carry multiple meanings and potentials for different contexts.

As the environmental crisis shows radical openness and contextuality, it shall be established that the environmental crisis can be reasonably deemed a complex system, as according to Chu et al. Due to the features of radical openness, formalising the environmental state of affairs into a system with complete boundaries may turn out to be challenging.

Some systems however show *irreducible* radical openness. In such an event, incorporating sinks and sources does no longer lead to reduced openness of the system. It shall be argued that irreducible radical openness emerges when attempting to define the environmental state of affairs as it is.

“An important case of irreducible radical openness are systems that transform their ambiance and are transformed by it on a relevant temporal scale.“ (p. 24) This means that whenever the mutual impact between an (assumed) system and its ambiance becomes so frequent that sources and sinks cannot meaningfully be located, the system shows radical openness that cannot be reduced. However, in order to “construct a workable model the scientist will have to select a relatively small number of elements of the system which he deems to be relevant.“ (p. 23)

It can therefore be helpful to discuss the epistemic implications of irreducible radical openness beyond modelling to then investigate the possibility of conducting science and policy despite such conditions.

Aiming to provide the reader with comprehensive information, all of the established terms describing conditions of complexity shall be summarised in table 1 below.

Table 1: Terms of Complexity

Term	Definition	Reference
Complexity	Consisting of many different and connected parts	(Soanes & Stevenson, 2005)
Complexity	A condition of complex systems, showing features of *radical openness* and *contextuality*	(Chu et al., 2003)
Radical Openness	A feature of complex systems; lacking full system boundaries and showing mutual impact between the system and its ambiance. Reducible by introducing informational input and output valves,	Inferred from (Chu et al., 2003)

	sources and *sinks*.	
Irreducible Radical Openness	A feature of complex systems; lacking full system boundaries,showing mutual impact between the system and its ambiance. Not reducible by placing sources and sinks.	Inferred from (Chu et al., 2003)
Contextuality	A feature of a complex systems; includes one or more elements that also occur in a different system(s) or if it is itself a shared element between more than one system and in this other system(s) the shared elements take part in causal processes different from those included in the original system.	(Chu et al., 2003)
Irreducible Complexity	A condition of complex systems; showing features of *irreducible radical openness* and *contextuality*	Inferred from (Chu et al., 2003)
Epistemic Complexity	The perceived incompatibility of a multitude of interconnected and sometimes conflicting sets of knowledge.	Inferred from various sources and reasoning.
Irreducible Epistemic Complexity	The perceived incompatibility of a potentially unlimited number of interconnected and sometimes conflicting sets of knowledge.	Inferred from various sources and reasoning.

2.2 Exhaustiveness and truth

The following section discusses the relationship between radical openness and epistemic complexity. Furthermore, the adjacent concept of *irreducible epistemic complexity* shall be established.

Whether for a wicked problem or a complex system, the features of radical openness and contextuality may be described as carrying the potential to generate epistemic complexity, which may occur as a condition perceived by the scientist or problem solver.

In an effort to exhaustively describe the environmental state of affairs as it is, the number of systems that may be reasonably considered mutually interrelated with the environmental crisis' state of affairs is potentially unlimited. Thus, in order to give an exhaustive description it, every interrelated system to the tree must be included in the system, in order for the description to be exhaustive: may it be global warming and its causes, biodiversity loss, ocean acidification, pollution in all its various forms, problems of waste disposal, the oil and gas industry and all its implications and consequences, mass consumerism, increasing demand for energy, questions of environmental governance and a number of other things. In an attempt to formalise all of these mutually interrelated systems, a scientist might aim to include every system that is interrelated with its antecedent, each arguably operating on various temporal and spatial levels, and each constantly impacting each other. This could leave the scientist in a state unwilling, and seemingly unable to exclude any of the systems mutually interrelated. This condition shall be referred to as *irreducible epistemic complexity*.

Similar to the relationship between radical openness and epistemic complexity as described above, in an instance where irreducible radical openness is present, a scientist or problem solver may find themselves in a state of irreducible epistemic complexity.

While *epistemic complexity* describes uncertainty in the face of multiple sets of knowledge, *irreducible epistemic complexity* describes uncertainty in the face of potentially unlimited sets of knowledge.

What may be concluded from the previous sections is the following: First, it shall be established that in the absence of system boundaries, conditions of epistemic complexity emerge. However, once system boundaries are placed, a scientist may enable themselves to generate knowledge with some degree of certainty.

Secondly, as acts of choosing system boundaries allow for the generation of knowledge, epistemic complexity is foundational to science, as its existence, even if unfavourable, may be deemed an inseparable part of the research process.

Additionally, if one were to conduct research without taking potential conditions of epistemic complexity into account, their research may not be fit to generate useful results.

2.3 Problem-solving despite uncertainty

In practical contexts, such as environmental governance, the significance of certain knowledge for successful problem-solving may however be questionable. This section shall discuss the possibility of finding useful problem-solving strategies despite conditions of epistemic complexity.

In order to do so, it may be helpful to recall the basic definitions for knowledge and truth. A standard, albeit not unproblematic, philosophical definition for knowledge is for someone to possess a "justified true belief" (Gettier, 1963) This definition contains the term "true" – however, the concept of truth is one of the unanswered fundamental questions in philosophy. It has been discussed for thousands of years and scholars have formulated many theories around the concept. However any method to prove something as true, naturally rests upon presupposed frameworks.[4] Still, as all lack of evidence suggests, there is no universally applicable standard to decide upon the absolute truth of any matter. "Explaining the nature of truth becomes an application of some metaphysical system, and truth inherits significant metaphysical presuppositions along the way." (Glanzberg, 2023) If the truth of a matter is dependent on metaphysical presuppositions, then no true belief can be justified outside of these presuppositions.

It follows that in an instance of radical openness, any two sets of knowledge could become equally true, as long as they are each true within their own epistemic framework. As such, one could never entirely escape the uncertainty that comes with epistemic complexity.

[4] Few scholars practising philosophy in recent times have contested this idea but have shifted to notions that could be described as organising different qualities, units and degrees of trueness to various instances of potential truth matters. Such notions include *truth bearers* and *verisimilitude*. (Glanzberg, 2023; Oddie & Cevolani, 2022)

Moreso in the presence of irreducible radical openness and the according conditions of irreducible epistemic complexity. If a problem solver were to insist on truth as a standard to guide their solution strategies, they would likely find themselves unable to proceed meaningfully, as the problem solver could potentially task themselves to find solution strategies within an irreducibly radically open system that contains a potentially infinite number of differing truths.[5]

One may even state that the relativism inherent to the concept of truth makes trueness irrelevant for problem-solving applications. Especially for cases such as environmental governance, the significance of truth may be lower than some would expect.

As universal truth as a concept loses significance, one's own state of uncertainty about the truth of any matter loses urgency. It is this approach towards epistemic complexity that may offer new possibilities in dealing with complex systems and complex problem structures.

As was established in chapter 1, solutions to complex problems are not true-or-false, but good-or-bad. "Normally, many parties are equally equipped, interested, and/or entitled to judge the solutions, although none has the power to set formal decision rules to determine correctness. Their judgments are likely to differ widely (...) Their assessments of proposed solutions are expressed as *good* or *bad* or, more likely, as *better or worse* or *satisfying* or *good enough*." (Rittel & Webber, 1973, p. 163)

Acknowledging a level of independence from truth for complex problems allows for researchers as well as policy makers to make attempts at resolving complex problems without worrying about exhaustiveness or claims to truth, since the objective shifts to quality (good or bad) rather than truth (true or false). "The quality of the scientific inputs to the policy process is known to be problematic. No one can claim "truth" for his results. Nor can uncertainty be banished, but good quality can be achieved by its proper management." (S. Funtowicz & Ravetz, 1994, p. 1)

[5] At such a moment, it is ultimately a semantic choice if one refers to such knowledge sets as true or false.

Concludingly, defining the environmental crisis in terms of choosing its system boundaries may justifiably so remain a matter of choice that could ultimately be informed by any number of research interests, even within strictly epistemic contexts.

If one accepts this argument, then the state of affairs as it is cannot be defined with certainty. Thus, Rittel and Webber's problem formula can not be solved with certainty. The formula can however be solved by choosing to take one (limited) perspective according to one's own research interest.

For example, the research interest of this thesis could be formulated as exploring ways to help the shift towards a state of the global ecosystem that is characterised by a climate no warmer than 2°C on average compared to pre-industrial times. As according to this interest come value judgements that render certain things, events and concepts as relevant and irrelevant for this endeavour, making it possible to frame the global environmental state of affairs alongside these boundaries.

One legitimate way of framing the environmental crisis may therefore be expressed as "a discrepancy between a global state of capitalism, neo-liberalism and nationalism and holding the increase in the global average temperature to well below 2°C above pre-industrial levels."

This framing of the environmental crisis is primarily political. It shall express the high level of power and agency that governance structures hold over the environmental state of affairs as it is. Capitalism, neo-liberalism and nationalism characterise a global economy that, undisguisedly so, holds profit and growth as a priority. Ways of sustaining such structures are partly ensured by nations competing in various markets — including markets such as renewable energy and climate finance, thereby inhibiting allocation of resources. 196 parties ratified the Paris Agreement as a "legally binding treaty", reportedly bringing "all nations together to combat climate change and adapt to its effects" (The Paris Agreement, 2016) economic structures have arguably not sufficiently adapted to this shared goal. While in some ways contributing to livelihoods of humans by providing economic security, concerns about ecological livelihoods for humans and other organisms seem to be second to sustaining economic development itself. The idea that economic growth is necessary for the livelihoods of all people on Earth has been criticised for decades, arguing that limitless economic growth can not sustain on a finite planet. (Meadows et al., 2017)

Chapter 3 will present problem-solving strategies from HPS and STS that employ epistemic complexity as a favourable condition.

Chapter 3

This chapter will present four notions that may be employed for problem-solving endeavours in the face of epistemic complexity. As such, they could be described as distinct in their formulation, but are intertwined in their underlying concepts. For this reason, the four notions will be discussed in two sections. Section 3.1 will encompass the *Precautionary Principle* and *Post-Normal Science* (PNS). Section 3.2 will encompass *Care* and *Tinkering*.

All four notions have significance for debates in Philosophy of Science (POS) and Science and Technology Studies (STS). STS is rooted in sociology and while interlinked, it is not primarily concerned with philosophical questions. In this way, notions from STS can offer perspectives that discuss knowledge from the sociological angle of theory and practice, while being informed by its (more or less) distinct discourses. POS, as the primary discipline in which this thesis is rooted, offers ways to deal with philosophical and epistemological questions. Both POS and STS are widely drawn upon in academia and other professional realms as ways to navigate the intersection of science and (environmental) governance. The four notions presented below were chosen with regards to their relevance for the thesis, as well as their relevance in the greater field of environmental governance.

In 2024, the EEA released a report titled “Governance in Complexity – Sustainability governance under highly uncertain and complex conditions” (European Environment Agency., 2024), exhibiting the European Union’s awareness about complexity in environmental governance and its ramifications.

“The report explores the concept of 'governance in complexity'. It is defined as the attempt to govern a system while being aware that it cannot be perfectly known or controlled, and actors of governance are themselves part of or interconnected with the system.” (European Environment Agency., 2024, p. 35)

In the report, *PNS*, the *precautionary principle* and *care* are among the discussed concepts. This EEA report will be taken into account for chapter 3 and chapter 4, as it is of high relevance to the topics of this thesis and may give useful insight into how questions of environmental governance are negotiated at the current time the thesis is written.

The notion of *tinkering* was chosen for its simple and straightforward principle and theoretical and practical interlinkedness with the principle of *care*. As a theoretical stance, tinkering showcases the useful and favourable features of uncertainty and complexity and aims to generate knowledge via experimentation (learning by doing). As shall be argued, the mentioned four concepts deploy strategies for practical application and problem-solving and are thereby less dependent on epistemic certainty. Applying notions of this kind may enable a problem solver to take advantage of the very instances that are regarded unfavourable in other epistemic contexts. In other words, a problem solver may not necessarily need to eliminate complexity, openness and contextuality, but utilise such conditions to their practical advantage.

All of the following problem-solving theories will be discussed with a focus on systems thinking, as referring back to the previous discussion of problem structures and complex systems. Systems thinking in the environmental governance context shall denote a theoretical perspective on (problem-)structures that takes into account the interrelations and interactions between and across systems and issues related to the governance field. As such, systems thinking may be regarded as "already represented in the knowledge base of environmental and sustainability governance (...)" (European Environment Agency., 2024, p. 40)

The following section shall guide the reader away from epistemological difficulties and uncertainties and rather point to the possibilities, opportunities and ways of engaging with problems that bear fruitful knowledge and unexpected solutions.

3.1 Precautionary Principle and Post-Normal Science

Put simply, the precautionary principle could be paraphrased as “better safe than sorry”. Behind this simple motto however stands a well-measured principle of risk management, that can be employed when faced with uncertainty about complex problems that need urgent solving. The precautionary principle first emerged in German law in the 1970s (as *das Vorsorgeprinzip*) and has since been generally endorsed for environmental governance.

“Over the past decades, the PP [precautionary principle] has become an underlying rationale for a large and increasing number of international treaties and declarations in the fields of sustainable development, environmental protection, health, trade and food safety.”, arguing for the “potential implications the PP may have for scientific and technological development”, which makes “it necessary to develop a common understanding of what the PP is (...) in order to facilitate standard-setting in this area, to raise awareness of the ethical notions up on which the PP is based, and to help Member States to build relevant human and institutional capacities.” (UNESCO, 2005)

In the European context, according to the European Parliament, the precautionary principle was applied within the EU for cases including the declining bee populations, fish-stock management and genetically modified organisms. (European Parliament, 2016)

Among other sources, the European Commission, the European Parliament, UNESCO and the EEA have formulated definitions for the precautionary principle. The European Commission defines it as: “an approach to risk management, where, if it is possible that a given policy or action might cause harm to the public or the environment and if there is still no scientific agreement on the issue, the policy or action in question should not be carried out. (European Union, n.d.)

Interpretations of the precautionary principle do vary according to the degree of uncertainty for which the principle may be employed meaningfully. In the context of the environmental crisis, the potential benefits of conserving natural sites and human health are obvious. In other cases, the absence of intervention can however potentially cause harm too. Various interpretations and definitions are occasionally described as "positive", "negative", "double negative" or "triple negative". This refers to the degree to which they are positive decision principles (that prescribes action to limit harm in the presence of some condition of uncertainty) or negative in the sense of providing an argument in favour of the lawfulness and legitimacy of an action in the absence of certainty.

While some viewpoints have argued the precautionary principle inhibits progress because it purportedly would slow down risk-taking and innovation, one of the economically striking arguments for it is the possibility to "reduce future costs for environmental and health expenditures". (European Parliament, 2016)

UNESCO established a set of conditions for which the precautionary principle may be employed meaningfully. This list of conditions is not to be understood as a normative framework across UN institutions, but rather a set of recommendations. "In summary, the PP applies when the following conditions are met:

• there exist considerable scientific uncertainties;

• there exist scenarios (or models) of possible harm that are scientifically reasonable (that is based on some scientifically plausible reasoning);

• uncertainties cannot be reduced in the short term without at the same time increasing ignorance of other relevant factors by higher levels of abstraction and idealisation;

• the potential harm is sufficiently serious or even irreversible for present or future generations or otherwise morally unacceptable;

• there is a need to act now, since effective counteraction later will be made significantly more difficult or costly at any later time." (UNESCO, 2005, p. 30)

Similarly rooted in environmental governance and risk management is the notion of post-normal science. PNS was introduced by Jerome Ravetz and Silvio Funtowicz in the 1980s and 1990s, who suggested to apply their frameworks for situations where "facts are uncertain, values in dispute, stakes high, and decisions urgent.” (Ravetz & Funtowicz, 2003, p. 1)

The recent EEA-report on complexity in environmental governance (European Environment Agency., 2024) discusses PNS as a relevant framework for current environmental challenges: “From a post-normal perspective, acting on systemic and complex challenges cannot be dependent on waiting for better knowledge. Instead, seeking ways to act and make decisions within uncertainty, complexity and controversy are the norms of environmental governance (…) ” (European Environment Agency., 2024, p. 26)

Post-normal frameworks may be applied to various contexts, historically PNS is however rooted in the analysis of the science-policy interface, particularly in questions regarding the quality of information scientists and other experts may provide to policymakers. As such, PNS recognises complexity as an innate condition in the scientific pursuit and more so as an innate condition in problems of global, environmental or otherwise public scope. In this way, PNS scholars will typically suggest to focus on quality over certainty – meaning that scientific information fit for policy purposes shall be judged by its quality to resolve the problem at hand, rather than its degree of epistemic certainty. In order to approximate such quality of information, appropriate attention should be given to the perspectives that various stakeholders involved in the problem hold.

Beyond the scope of the precautionary principle, PNS offers two types of frameworks. First, the theoretical framework of PNS employs ways of knowing that typically suggest elements of public participation and an extension of the peer community in order to diversify knowledge generation processes. Wicked problems, as discussed in chapter one and two, are problems that often transcend epistemic frameworks of scientific disciplines, leading to uncertainty for the problem solver. Epistemic frameworks however may also transcend the domain of science, policy and expertise. As environmental issues do affect non-experts, non-scientists and non-policymakers, PNS (and many other) scholars argue for taking non-expert knowledge into account as a necessity for the science-policy intersection, as to provide policymakers with scientific information of good quality.

“In those circumstances, the quality assurance of scientific inputs to the policy process requires an ‘extended peer community’, consisting of all those with a stake in the dialogue on the issue.” (...) It has hitherto been a well kept secret that scientific ‘facts’ can be of variable quality; and an informed awareness of this human face of science is a key to its enrichment for its future tasks.” (S. O. Funtowicz & Ravetz, 1993, p.30)

The other framework that PNS offers may serve as practical guidance for risk management. In 1985 Funtowicz and Ravetz established the underlying ideas for PNS in a paper titled “Three Types of Risk Assessment. A Methodological Analysis.” (1985). The term itself however only appeared a few years later, in the paper “Science for the Post-Normal Age” (1993).

Their proposed three types of risk assessment were: Applied science, technical consultancy and total-environmental assessment (“post-normal science” in later works). The chart below (see figure 1) displays a guide on which type of knowledge shall form the basis for its according type of assessment. The y-axis displays decision stakes, while the x-axis displays system uncertainty.

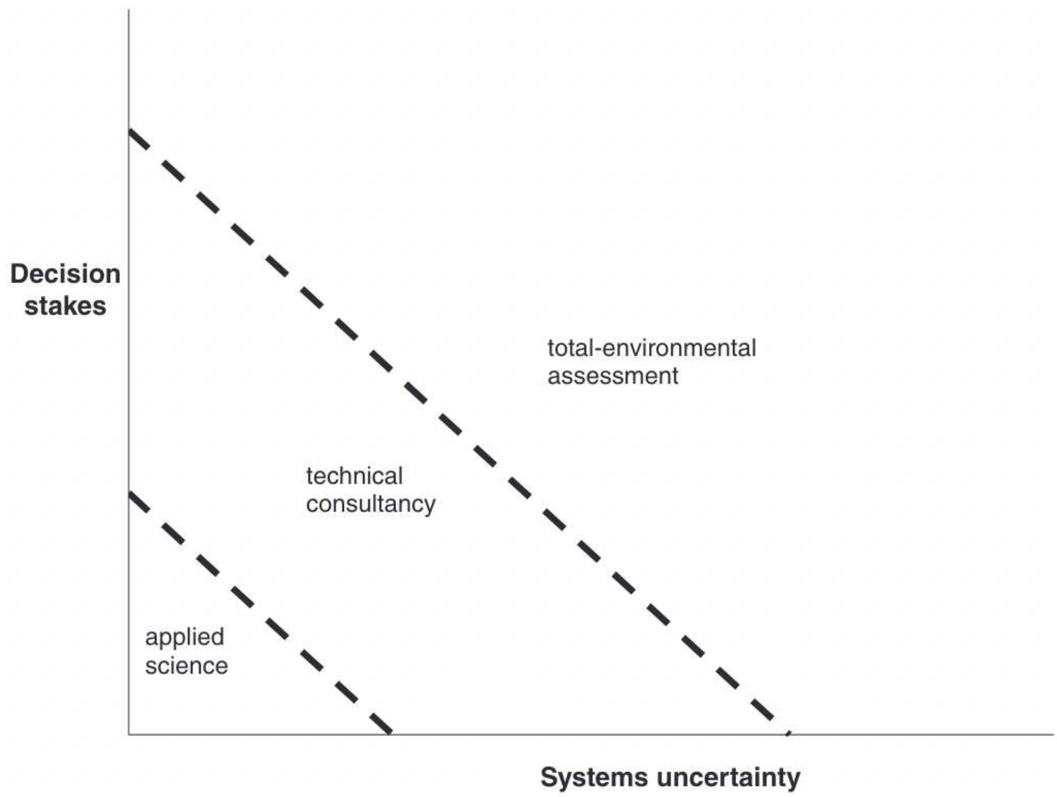


Figure 1: Three types of risk assessment by Funtowicz & Ravetz, taken from (Strand, 2017, p. 290)

The bottom left section shows that when uncertainty and decision stakes are relatively low, one may (simply) employ applied science. The middle section shows that when uncertainty and decision stakes are moderately high, a professional consultant shall provide their experience (from applied science or equivalent) as expertise to reduce the system's uncertainty. In this way, a problem solver may consult a technical professional in order to improve the knowledge basis for finding problem-solving strategies, thereby reducing uncertainty. A problem solver may also consult a technical professional to judge upon the decision stakes of the problem at hand. This consultant may apply technically informed value judgements, in order to decide upon the type of solution necessary, as well as its urgency. Often, there may also be an implicit understanding that the consultant remains loyal to the perspective and value preferences of their problem solver, or client. The third section of the diagram displays instances where decision stakes and uncertainty are so high that technical consultancy stops being useful, for

example in the way that there is no single and unique perspective and value preference on the side of a client, or that it is heavily contested in public as a matter of controversy. In later works, these instances would be referred to as "post-normal problems".
It is argued that decision stakes should be regarded as subjective, thereby requiring the value judgement of a person, since "not by logical necessity but as a matter of fact, high decision stakes also tend to be connected to disagreements about the stakes and the underlying value judgements between different stakeholders and affected parties." (Strand, 2017, p. 290)

Post-normal problems typically involve a large variety of stakeholders, with various and thereby sometimes conflicting perspectives over questions such as, which solution strategy shall be applied to the problem, what shall be the desired outcome, or how to define the problem at hand. As such, many environmental governance issues may be regarded as post-normal problems. In such cases, Funtowicz and Ravetz suggest a "total-environmental assessment". Here, the term "environmental" is not to be understood in the sense of the natural environment but rather to include all relevant parameters that are related to a given problem.

For this purpose, Funtowicz and Ravetz created a system of notations where different types of uncertainty pertaining to (scientific) information can be expressed and interpreted. NUSAP is an acronym for numeral, unit, spread, assessment and pedigree. "Pedigree (...) is the post-normal or mildly constructivist innovation in this system. The pedigree of a number or a fact can be elicited and communicated through tailored sets of descriptors, for instance on the level of expert agreement, quality of data, the use of models, and the level of maturity of underlying scientific theory." (p. 295)

The NUSAP.net website offers general information on NUSAP, uncertainty and risk assessment as well as tutorials and interactive tools to teach users how to use the system. (S. Funtowicz & Ravetz, n.d.)

Funtowicz and Ravetz argue that for problems of such scope as environmental governance, a linear methodology "of laboratory research" (Rittel and Webber perhaps would refer to it as *tame*) would be unlikely to provide guidance for solving the complex issues involved. "However, emerging environmental problems do not render the use of traditional scientific approaches irrelevant; the task is to choose the appropriate kind of scientific problem-solving strategy for each particular issue. This is why we have a detailed discussion of applied science and professional consultancy along with post-normal science." (S. Funtowicz & Ravetz, 1994, p. 2)

The term "post-normal" itself alludes to Thomas Kuhn, who proposed that the scientific enterprise historically evolved by the continuous and repeated passing through of two different stages: the stage of *normal science* and the stage of *scientific revolution*. In "The Copernican Revolution" (1957), Kuhn describes the transition from a geo-centric to a helio-centric understanding of the universe as such a paradigm shift. In the 16th century, the astronomic discipline transitioned from practising *normal* science within the Ptolomean, geo-centric paradigm, to the *revolutionary*, helio-centric Copernican paradigm. With a few alterations, the Copernican paradigm is still in effect in 2024. Thus, the Copernican paradigm has become part of the current *normal science*, which could possibly transition into another *stage of revolution* in the future.

Kuhn further distinguishes between *mature* and *immature* science. Whereas mature science is a stable paradigm, according to Kuhn, immature science is a term that refers to knowledge and methodologies that are contradictory and dysfunctional. Scholars of PNS however take the position that the scientific enterprise has moved beyond Kuhn's conceptions and into the post-normal age, where the separation between normal science, scientific revolution, immature and mature science is not fully justified. For issues of public scope, conflicting epistemologies as well as value judgements of various stakeholders are a given and must be taken into account, well-measured and applied in problem-solving strategies.

As such, potential sources of epistemic complexity are not simply ignored or denied, but when a framework such as PNS is applied, the consequences and ramifications of what epistemic complexity entails can transform. When faced with the task of defining the environmental *state of affairs as it is and the state of affairs as it ought to be*, a PNS scholar would presumably choose to extend their peer community and involve as many stakeholders (then also understood as *knowledge holders*) as possible in order to collect relevant input. At the same time they would gladly receive personal value judgements from both expert and non-expert stakeholders and weigh the outcome against the existing decision stakes, for example by applying a system such as NUSAP. As such, a PNS scholar might (but by no means necessary) understand the environmental crisis as a post-normal problem that may resist a complete solution but that may be resolved by deliberating within imperfections and in the presence of irreducible value conflicts.It shall be noted that PNS should not be understood as a source that provides instructions for success, but mainly as a way of understanding why public controversies around technical and environmental problems tend to last in spite of attempts of providing technical solutions to them. It has been pointed out that the desire for technical solutions may be part of the problem complex. In this way, PNS aligns itself with broader theoretical developments in sociology that advocate institutional development at the interface between science and (late modern) society (Strand, 2017)

3.2 Care and Tinkering

Although care is an established concept, primarily in feminist theories including philosophy, sociology as well as POS and STS, unsurprisingly, there is not a singular definition for it. As a basis of principle, it does however employ the meaning of care as the term is used outside of academia. Therefore, one initially may take the freedom to rely on their own, intuitive understanding of care, which many persons may have been introduced to by their mothers or similar figures in life.

In many ways, care is intertwined with tinkering. The basic principles that are underlying both of the two terms are focused on reflection and adaptation, rather than working towards a particular outcome. Both the notion of tinkering and care are less reliant on certainty and could thereby be more suitable to deal with features of openness and contextuality. Taking a perspective that is informed by such principles may enable a problem solver to make use of conditions of complexity rather than trying to avoid or combat them.

It shall be argued that in the face of conditions such as irreducible epistemic complexity, it is not by necessity that one must, by all means, find a way to draw system boundaries, as to reduce uncertainty. In some instances it can be more effective to rather change one's own perspective towards the problem structure, rather than trying to change the structure itself. In the context of notions like PNS, care and tinkering, openness is not necessarily considered an unfavourable condition but a condition that could be innate and legitimate to a given problem structure. It appears that some problematic conditions can be resolved by simply ceasing to treat them as problematic. In this section, it will be explored how care and tinkering may become useful in the face of conditions of complexity for problem-solving endeavours.

Among others, care can involve practices of looking after, sustaining, and nurturing relationships, objects, and systems in ways that promote well-being and flourishing. "(...) care implies a negotiation about how different goods might coexist in a given, specific, local practice." (Mol et al., 2010).

Conceptually, care shall denote the primary means of engaging and interacting with a subject, while continuously adapting to changes of its state, rather than attempting to define its status in terms of a set definition. Caring for a person or subject that is prone to change requires reflexivity and adapting. The following attempts to present care and tinkering as understood in the academic discourse of POS and STS.

In STS, care refers to a theoretical framework that was (at least in part) born from research done by the social psychologist Carol Gilligan, studying differences in ethical and moral developments of young boys and girls. Carol Gilligan may be regarded as a pioneering figure for the field of feminist theories in STS and POS. Her book "In A Different Voice: Psychological Theory and Women's Development" (Gilligan, 1982) has prompted scholars from various fields in philosophy and sociology to apply some of its concepts and insights (Code, 2015; De La Bellacasa, 2011; Haraway, 2016; Lindén & Lydahl, 2021; Martin et al., 2015; Mol, 2008) In the book, Gilligan observes that there are considerable differences in the moral development between genders. The book establishes that young boys tend to be socialised to aim towards moral qualities related to independence, individual justice and impersonal ethics. In other words, young males would be empowered to “claim their fair share”. Young females however tended to be socialised to aim at moral qualities related to ethics of interpersonal relationships, collectivism, and care. Socially however, Gilligan argues, there exists a bias that ascribes higher value to typically masculine ways of feeling and thinking, leading to an imbalance between what is socially and politically favoured and rewarded.

Gilligan suggests that “separation and individuation are critically tied to gender identity” (Gilligan, 1982, p. 8) arguing that typically, masculine development values instances of autonomy and independence while intimate relationships or other persons in general can be viewed as obstacles for such qualities. This perspective is sometimes referred to as the “perspective of justice” (Norlock, 2019). Young women on the other hand were expressing the perspective of justice too, however “as likely” to express a perspective of interpersonal relationships, intimacy and caring. (Gilligan, 1982, p. 48) This may be referred to as the perspective of “care” (Norlock, 2019).

Scholars of various disciplines and interests have explored the power dynamics in gender contexts for epistemic knowledge generation as well as the social, political and practical implications of such dynamics.

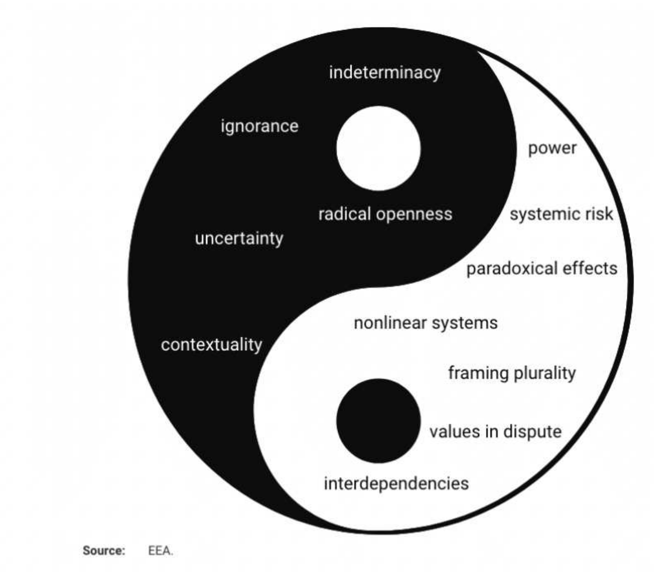
Applying care as an epistemic practice calls for a reflexive and critical stance towards science and technology and advocates for inclusive, democratic, and equitable approaches to knowledge generation. In this way, interrelatedness as well as interpersonal relationships play a significant role in generating knowledge through care.

For implications of the social and political realm, it is argued that Western societies tend to uphold qualities associated with the male moral development, such as rationality, individual pursuit of success and objectivity. Qualities associated with female moral development, such as interpersonal relationships, qualitative values and care, are deemed less valuable in power contexts. (European Environment Agency., 2024) A separate specialised field of care studies “environmental care theories”, exploring the interrelations of humans, non-human animals and their environments. (Norlock, 2019)

In the recent EEA report on complexity in governance (2024), it is argued that “this trait of modern societies is also naturally reflected in European institutions of governance, both in their preference for standardised procedures and in their implicit view on scientific knowledge as objective and value-free (…) sectoral governance frequently exists in the tension between the norm of impartiality and objectivity on one hand and the care for its particular sector on the other.” and further that “Typically, a care approach would not focus on making a plan, model or a set of standards but instead directs efforts towards doing something for humans, animals, plants, places and other elements that we care for. (…) (European Environment Agency., 2024)

While overall alluding to a gentler approach to the environment and people, the concept of care should however not be understood as being innately morally superior to other concepts. While feminist scholars have argued for the legitimacy and significance of qualities associated with female moral development, the qualities associated with male moral development shall not be disregarded. “(...) in the context of governance in complexity, the principle of care is accordingly also a matter of managing and possibly including a plurality of perspectives and stakeholders, dealing with multiple values and ways of valuating through participatory initiatives. (European Environment Agency., 2024) The EEA argues that governance in complexity would need to manage putting both of these aspects into action. Ideally, environmental governance should thereby be characterised as adaptive and intuitive as well as assertive and affirmative. This would however require “humility and respect for the magnitude of the challenge.” Key principles of governance in complexity include experimentation, systems thinking, participation, precaution, anticipation and care. (p. 35, p. 38)

The same report shows two explanatory diagrams, displaying this dichotomy alongside the yin-yang symbol from Chinese philosophy.



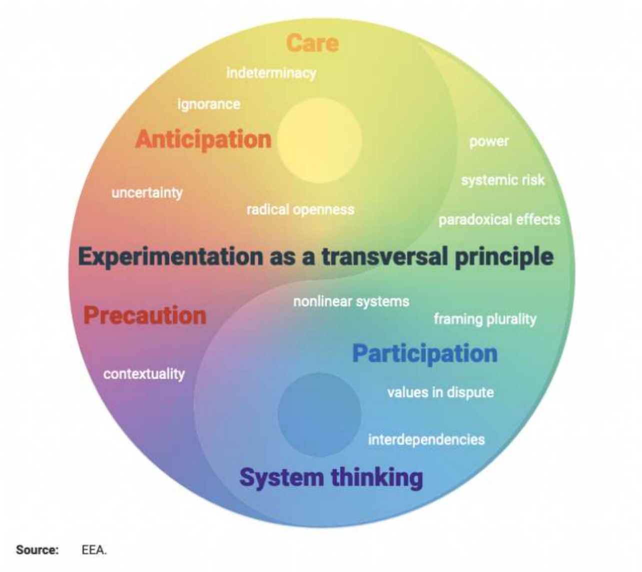


Figure 2, left: "Descriptors of systemic and complex challenges, ordered in a fish-shaped yin-yang taiji map" (p. 37)

Figure 3, right: "An approximate correspondence between descriptors of systemic and complex challenges and principles of governance in complexity" (p. 44)

In the left diagram, it shows yang, the white portion of the symbol, as the "assertive" posture, providing "affirmative characterisations and knowledge claims, actions and governance approaches". This yang perspective recognises the world as a complex system with multiple, "interrelated drivers of change". It stands for the belief that improving one's scientific understanding of the system will lead to better or easier governance of it. While surely being "prone to imprecision and error", it will get "the job done of improving sustainability." The yang posture favours rationality, agency "and asks for 'solutions' (…) using force to create impact" (European Environment Agency., 2024, p. 37)

The black yin portion on the other hand represents adaptiveness, uncertainty and epistemic multiplicity and "will not act as if the absence of evidence of harm equates to evidence of absence of harm" (p. 37) in a way representing a standpoint in favour of the precautionary principle. The adaptive yin points towards "radical" change, transformation, institutional change, public participation and new social practices. "This type of action may be seen as distinct from conservative policy discourses that typically favour assertiveness over adaptiveness. Adaptiveness "(…) has been traditionally associated with less prestige or symbolic and institutional power. More assertive ways of knowing and acting have dominated institutional discourse." (p. 38)

Similarly, examples of governance in complexity can be displayed by using the same yin-yang shape in combination with their according principles, illustrating their possible approximate domain by colour shades, as illustrated in figure 4 above. As most significant for the specific discussion within this thesis are the principles "care" situated in the top yin portion of the map and "system thinking" situated in the bottom yang portion.

Another notable philosopher and theorist who ought to be mentioned in this respect is Donna Haraway, whose works are typically centred around the sociological, philosophical and political aspects of the relationship between humans and their surroundings. In recent works, she has focused on interrelations of humans, animals, biology and art. (Haraway, 2008; 2016) As such, Haraway has not written extensively on the epistemological practices of care as they are discussed within this thesis, unless one considers new practices of conviviality with other species (what Haraway refers to as "oddkin") as in part an epistemic project. However, her works are much cited and analysed (among many others) by scholars of care theories, such as María Puig de la Bellacasa.

One of Puig de la Bellacasa's central works is the book "Matters of Care. Speculative Ethics in More than Human Worlds". (Puig de la Bellacasa, 2017) The title stands in relation to one of Bruno Latour's well-known works "Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern" (2004) As much of Latour's work was dedicated to theories of the construction of facts and his contributions to Actor-Network-Theory (ANT), Latour describes the ontological interrelations between humans and things. In his prominent book “We Have Never Been Modern” (1994), Latour argues that an essential feature of modernity is the common social narrative that facts and values are distinct from one another, while they may be most reasonably regarded as intertwined. Later in Latour’s scholarship, the hybridity of facts-values and nature-culture entails a shift of approach towards things as matters of concern, involving to recognise the dynamics of facts and values, rather than approaching things as rigid matters of fact. As such, one may deem some of Latour’s concepts as extensions of the concept of care.

In “Matters of Care: Speculative Ethics in More Than Human Worlds”, Puig de la Bellacasa discusses care as *care ethics* in relation to feminist theories and STS. She analyses Latour’s conceptions of matters of concern and discusses the politics and epistemologies of knowledge generation. Puig de la Bellacasa extends matters of concern to matters of care, which she distinguishes by their degree of active doing. “One can make oneself concerned, but “to care” contains a notion of doing that concern lacks.” (Puig de la Bellacasa, 2017, p. 42). As such, matters of care become more tightly interlinked to the socio-political implications of knowledge generation. To this point, she emphasises that caring can never be neutral, as interpersonality and value judgements are necessities for the act of caring.

The second chapter of the book is titled “Thinking with Care” and engages with Donna Haraway's work on the concepts of *situated knowledges*, *diffraction* and *worlding* through which Puig de la Bellacasa formulates care as “not only relational, (...) but also as condition (...)” allowing her to “step away from understanding care as part of a moral order or obligation” but something distinct from “hegemonic” formulations of ethics. (Türer, 2020)

Puig de la Bellacasa also attends to the non-innocent side of care by exploring reciprocity as a part of it. She argues that in caring not “every giving involves taking, nor every taking will involve giving’ (Puig de la Bellacasa, 2017, p. 121). Puig de la Bellacasa does not primarily advocate for a particular way of caring but rather discusses various questions around the topics of care, ethics and “non-human and human relationalities”. (Türer, 2020, p. 426)

The final scholar of care that shall be mentioned in this thesis is the philosopher and ethnographer Annemarie Mol. Some of her work on care explores the primary, non-abstract meaning of care, as in caring for persons. Her book “Logic of Care. Health and the Problem of Patient Choice” (Mol, 2008) describes the significance of ways of caring for people living with diseases. Mol argues that the practised logic surrounding care work for patients is a *logic of choice*, which to a degree undermines her conception of a *logic of car*e.

Logic of choice denotes a stance towards patients that advocates for autonomy and agency of the person in need for care. Mol explains that often, patients are treated as objects, and thereby made passive, which is a practice that is unfavourable in many ways. People in need of caring should be granted their right to make choices about their lives for themselves. (p. 6) Mol however argues that this logic of choice can critically fail to meet the needs of patients too. “(...) choice may be a great ideal, but only in situations in which people are indeed able to make their own choices. When they are patients, people often lack this ability.” (p. 6) Additionally she points out that making choices can be a complicated and varied task for any person, ill or healthy. “It is difficult for all of us to weigh up the advantages and disadvantages of one uncertain future against another. We tend to make incorrect assessments (...)” (p. 6)

In her book, Mol avoids making strict comparisons between dichotomies but rather proposes her theories by exemplifying blurred lines and clearing them up where need be. As such, she discusses the relationship between the logic of choice and the logic of care alongside the terms “cure” and “care”: “In scholarly discussions about health care, ‘care’ is often distinguished from ‘cure’. If this is done, the first term, ‘care’, is used for activities such as washing, feeding or dressing wounds, that are done to make daily life more bearable. The second term, ‘cure’, resonates with the possibility of healing, and is applied to interventions in the course of a disease.” (Mol, 2008, p. 1) The differences between “cure” and “care” may also indicate similarities alongside the yin and yang concept presented by the EEA. Whereas “cure” is directional and aiming to achieve a certain goal, “care” is reflexive and adaptive.

Mol reveals some of the crucial differences in the respective outcome when applying either meaning of the terms.

"In what kinds of practices do 'situations of choice' arise? By shifting focus in this way it becomes possible to show that the ideal of choice carries a whole world with it: a specific mode of organising action and interaction; of understanding bodies, people and daily lives; of dealing with knowledge and technologies; of distinguishing between good and bad; and so on. Instead of hinging on people's limited abilities, my doubt has to do with that entire world. A world infused with what I will call the logic of choice. It does not offer a superior way of living. More specifically: it does not offer a way of living superior to the life that may be led in a world infused by the alternative that this book seeks to articulate: the logic of care." (Mol, 2008, p. 7)

Mol argues for a "relational logic of care" that is focused on every day living of patients, stating that creating more opportunities for patient choice will likely not benefit health care, as good care must follow logics of care.

As for care, instances of epistemic complexity for problem-solving endeavours lose a great portion of significance. In applying care, a predefined outcome is not a primary goal. When practising care, the task of defining the environmental *state of affairs as it is and the state of affairs as it ought to be*, one would presumably choose to focus their work on reflexive doing and continuous adapting, and as such disregard the insisting on such definition overall.

Notions of care put emphasis on adaptiveness, reflexiveness and quite explicitly avoid focusing on a predefined (desired) outcome. Good care may be understood as making appropriate choices over which caring practice to apply for a given situation and the ability to reflect upon and change the practice if needed. As such, not only the state of affairs as it is but also the state of affairs as it ought to be might change at any given point. A well-versed practitioner of care may generate knowledge from within this dynamic.

3.3 Tinkering

The practice of tinkering may for many be primarily associated with the fixing or repairing of an object, or possibly the creative making of a thing. The notions of tinkering in the context of knowledge generation and problem-solving are not far from this primary meaning. Tinkering, similar to care, may be regarded as an aspect elemental to the basic human practice. In its broadest sense, tinkering shall denote the continuous reapplication of problem-solving strategies. Experimentation is the essential technique in tinkering.

It shall be emphasised that the notion of tinkering does not possess the human and interpersonal dimension that care exists in. In other words, it could be a good idea to tinker with objects or abstract structures, but not people.

It could be observed that a tinkerer will often have a predefined, desired outcome in mind when tinkering with something. For a practitioner of care, the mode of practice is often more important than the desired outcome. A tinkerer however may typically place some importance on the desired outcome but little importance on identifying the appropriate mode of practice, or solution strategy. This approach is to an extent implied for the act of experimentation.

As such, tinkering becomes particularly meaningful in a context where one is unsure about how to get to a certain end goal, such as limiting the global average temperature as according to the Paris Agreement. Tinkering is both learning by doing and doing by doing. In tinkering, the level of accuracy in describing the *state of affairs as it is* is not as significant as *the state as it ought to be*. Indeed, the state as it is is continuously and actively being altered and improved. It can be an approach that adapts to the openness of a given problem, as tinkering allows for failures and potentially endless re-tries. One might state that since the process of tinkering is focused on active doing, rather than passive reasoning, difficulties regarding epistemic complexity lose their significance.

However, good tinkering shall not denote the experimental application of random solving attempts. It shall be argued that good tinkering processes are well-informed by the tinkerers' reflexiveness and experience. With each attempt, a good tinkerer is able to generate knowledge about what they have at hand. One may argue that in this way, a good tinkerer *cares* for the thing.

The concept of tinkering is often associated with the field of *maker culture*, which encourages individuals to engage in DIY (do-it-yourself) projects and hands-on experimentation. Maker culture may be found in professional and private contexts related to potentially any kind of knowledge generation and application. Often, it can be found in computer and hacker-space related communities as well as crafting and applied arts. “Makers give it a try; they take things apart; and they try to do things that even the manufacturer did not think of doing. Whether it is figuring out what you can do with a 3D printer or an autonomous drone aircraft, makers are exploring what these things can do and they are learning as well.” (Dougherty, 2013, p. 7)

One of the key aspects of tinkering is the idea of re-iteration. Through repeated cycles of experimentation, observation, and refinement, tinkerers are able to improve their understanding of a problem or system and develop more solution strategies to apply. Tinkering is a dynamic and iterative process that encourages learning from mistakes, adapt to changing circumstances, and continuously improve. (Smith, 2023)

In academia, the theoretical notion of tinkering has been explored in various disciplines, including psychology, education and sociology. (Bevan et al., 2014; Griesemer, 2011; Jungnickel, 2015; Mol et al., 2010) Here, more specifically, tinkering refers to the act of making small, experimental changes or adjustments to an object or system in order to learn more about how it works. It is a hands-on, trial-and-error approach to problem-solving that emphasises creativity, curiosity, and exploration. (Rachelle, 2012)

Tinkering has been shown to have a positive influence on students in open-ended making activities. “(...) in education contexts like schools, museums, libraries, and after-school programs, research shows that if the invitation to creativity is accompanied by intentional structure and guidance, maker activities can be channelled to support deep student learning" (Bevan et al., 2014, p. 28) Tinkering activities are often designed to "support engagement, intentionality" and "innovation" to provide opportunities for learners to engage in practices that are "both epistemologically and ontologically meaningful". (Petrich et al., 2013, p. 53)

The notion of tinkering as here described appears to align closely to what the EEA has described as the principle of "experimentation" (2024). In their report, the EEA emphasises experimentation as a fundamental, transversal principle of governance in complexity: "In systemic and complex challenges, there is no blueprint or control. Accordingly, governance in complexity is a largely uncharted terrain and approaches must be invented, improved, and tested by trial and error. (...) To accept failure and error as key elements along the path to sustainability is in itself part of experimentation and a practice of humility." (p. 39) Within the institutional and political context of the EU, however, such an argument for experimentation is by no means trivial, as it can be interpreted as an implicit recognition that things are not under control and that problem-solving approaches that allow trial and error are called for.

With regards to the yin-yang map provided by the EEA, one may situate tinkering close to care, within the black yin portion of the circle. When applying solution strategies that are focused on the white yang portion of the circle, instances of complexity may be perceived as difficult and unfavourable. A tinkerer however may treat openness and contextuality as favourable conditions, as they provide more options and possibilities for experimentation. It could be argued that instances of complexity are in part enabling features for the practice of tinkering itself.

Chapter 4

The final chapter of this thesis shall provide the reader with a discussion and conclusion of the three main chapters. The discussion will re-situate every part of the thesis within a conclusive reiteration of the main points of the thesis. As such, the approximations, insights and results from each section will be re-visited and brought into perspective, particularly in order to formulate a response to the research question that was posed in the introduction: What can conditions of epistemic complexity offer for problem-solving endeavours in the interface of environmental science and policy?

As a final, additional section, some thoughts shall be shared that were gained during the research and writing process, that however did not find their rightful place within the main body of the thesis. This section is titled “ontological complexity”. It will offer a philosophical reflection on what may be the three main forces that together have generated and continue to generate the environmental crisis: *Humans* making *formalisations* of *nature*.

Discussion & Conclusion

It may be meaningful to re-visit the basic definition of complexity in order to make light of the core ideas that have been explored in the main three chapters of this thesis. In its broadest sense, complexity has denoted “consisting of many different and connected parts” (Soanes & Stevenson, 2005). It has further been argued that complexity is a feature of what we refer to as the “environmental crisis”, whereas the “environmental crisis” has, in its broadest sense, been defined as “the sum of the environmental problems that we face today.” (Soanes & Stevenson, 2005) It may be easily understood that “complex” is an appropriate adjective for this sum of issues, each intricate in its own way. As was established, the environmental crisis does not only consist of the issues and features that are encompassed by climate change. Moreso, the (itself complex) issue of climate change is merely one part of the environmental crisis. However, the environmental crisis further includes, among others, questions of socio-political scope, sustainability, economy and governance. In addition to showing complexity as a feature, the environmental crisis encompasses complexity as the theoretical concept that is discussed within this thesis. As such, complexity may be regarded as a core concept innate to the crisis, but also as a meta-concept by which one may attempt to study the crisis.

This previous style of description may be equated to a systems thinking approach, which is characterised by to some extent reductionist approaches to formalise a collection of affairs into an orderly structure. In section 2.1, complexity, as a feature that is observable in complex systems, has been analysed to possess the two conditions *openness* and *contextuality*. The complex system *environmental crisis* shows radical openness in the sense that it poses (close to) impossible to formalise every aspect of it into an orderly or complete structure.

The term “environmental crisis” is a comprehensive and arguably necessary choice of word to express the interlinkedness of the sum of the environmental problems that we face today. Semantically, it could however seem like a mere umbrella term, as such messily collecting any issue and concept under it that may be deemed relevant by the user of the term. This argument shall be deemed legitimate in part.

However, as one may choose to burden themselves with the task of understanding some of the perceived difficulties in this realm of environment and governance, one may find that the multiplicity of relevant factors and concepts subsumed under the umbrella term "environmental crisis" legitimately stands in accordance with the realities of various decisionmakers. The SOER 2020 report by the EEA , as discussed in section 1.1, speaks to this point. As one recalls some of the analyses given in the report, it may become apparent that instances of complexity are causes for why the EEA deems "insufficient action" taken by the EU to meet their sustainability goals, first and foremost by failing to develop appropriate institutional structures that could respond to the complexity of environmental challenges. (European Environment Agency, 2019) As such, the term "environmental crisis" reflects the messiness of the governance issue *environmental crisis*.

In this way, environmental crisis may denote a collection of issues including climate change, biodiversity loss, scarcity of drinking water, renewable energy and more. Many of the relevant issues are reflected in the UN Agenda 2030, the Sustainable Development Goals (United Nations, n. d.). It shall be however emphasised that the SDG's are not primarily directed towards the natural environment. When learning about the history of the concept of Sustainable Development, one may conclude that politically, it denotes the idea that the well-being of the Earth's ecosystem, global social development and a strong global economy are mutually dependent.[6]

Apart from climate change, biodiversity loss and some aspects of the SDG's, *environmental crisis* also encompasses the various ways of knowing that are tied to a variety of fields, including scientific as well as non-scientific knowledge. Some of these are: conservation biology, environmental engineering, environmental economics,

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[6] Indeed, the International Chamber of Commerce (ICC) was a key actor in the first United Nations Conference on the Human Environment in Stockholm 1972 and subsequently a key player in intergovernmental environmental governance. It seems that the ICC had significantly contributed to "a neoliberal vision that emphasised the market mechanism and business self-regulation as sources of environmental governance." In harsh contrast to the years leading up to the 1972 Stockholm Conference, by the 1990s, it was a widely accepted narrative that the protection of the environment as well as social development implied economic growth. (Bergquist & David, 2023)

atmospheric science, oceanography, environmental sociology as well as political theory and history.

In an attempt to formalise all of these aspects into a system as well as all of the aspects that were not mentioned here, as well as the factor of change, as time progresses, each aspects mutually transformative and prone to various implications as placed in contexts to one another – thereby showing *contextuality* – one may find themselves unable to complete or close said system. It has therefore been argued that the complex system of the environmental crisis shows epistemic complexity. Epistemic complexity has been defined as the perceived incompatibility of a multitude of interconnected but sometimes conflicting sets of knowledge, often leading to a state in which one is unsure about whether something may reasonably be called *true*.

In sections 2.1 and 2.2 it was argued that striving for exhaustiveness for the purpose of diminishing epistemic complexity may not be achievable as long as one insists on a particular degree of certainty or truth. If one's aim is to find solutions for a problem, it could be enabling to accept some degree of uncertainty.

This argument is not only implied in the reviewed literature on complex systems but also in the discussed literature on *wicked problems.* (1973) Rittel and Webber describe problems that are *tame* as in contrast to problems that are *wicked*: whereas the closed problem structure of a tame problem allows for a limited number of possible definitions and solutions, the openness of a wicked problem allows for a potentially infinite number of definitions and solutions. By analysing their work on wickedness, it was established that the environmental crisis may reasonably be deemed a wicked problem. (Notably, a wicked problem as in terms of a rationalistic, reductionist point of view.) Whereas Rittel and Webber emphasise that wicked problems cannot be solved, chapter 3 of this thesis focused on possible ways of knowing and doing despite conditions of wickedness or complexity.

For this purpose, four notions from POS and STS were presented and discussed with regards to their relevance for (environmental) governance. In 2024, the EEA released a report (European Environment Agency., 2024) that explores “governance in complexity”, which is defined as “the attempt to govern a system while being aware that it cannot be perfectly known or controlled, and actors of governance are themselves part of or interconnected with the system.” (p. 53) The *precautionary principle*, *post-normal science*, *care* and *tinkering* were discussed in light of this report.

As for the purposes of this thesis, perhaps the most important input from the report are the yin-yang maps, again displayed below, and their complementary descriptions in the report. The map on the left shows features of complexity and complex problems as they may occur in the governance context, each situated either the black yin or its complementary white yang area of the circle. This allows for an understanding of the variety of attributes that complexity can encompass. On the right is another yin-yang symbol showing the corresponding principles for governance in complexity.

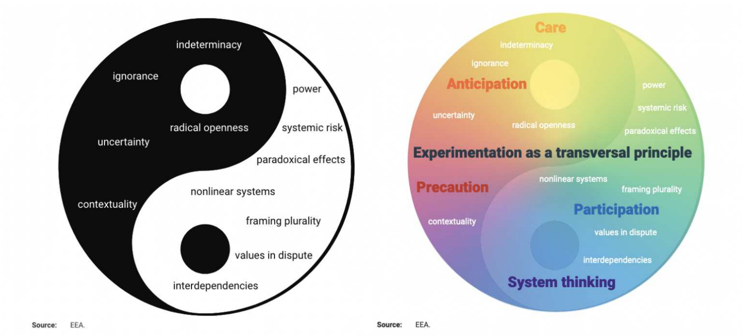

Figure 2 and 3. (European Environment Agency., 2024)

The EEA argues that governance in complexity would need to manage putting both of these aspects into action. It would ideally show adaptiveness as well as intuitiveness, assertiveness and affirmativeness. This would however require “humility and respect for the magnitude of the challenge.” (p. 38)

It was argued that it is not by all means a necessity to reduce any condition of complexity for any kind of problem-solving endeavour. It could be that in some instances it poses more effective to instead change the strategy one applies, rather than attempting to change the problem. Arguably, for all four notions presented, complexity is not necessarily considered a hindrance but a feature that is legitimate and as such innate to many problem structures.

One could summarise the precautionary principle with the phrase “better safe than sorry”. This however well-measured principle has since the 1970s been generally endorsed for environmental governance.

The frameworks of post-normal science are rooted in the analysis of the science-policy interface, particularly in questions regarding the quality of information scientists and other experts may provide to policymakers. PNS scholars will typically suggest to focus on quality over certainty and to give appropriate attention to the perspectives of various stakeholders involved in a problem.

It is as such interlinked with the concept of care. “(...) the principle of care is accordingly also a matter of managing and possibly including a plurality of perspectives and stakeholders (European Environment Agency., 2024) Notions of care put emphasis on adaptiveness, reflexiveness and quite explicitly avoid focusing on a predefined (desired) outcome. Good care may be understood as making appropriate choices over which caring practice to apply for a given situation and the ability to reflect upon and change the practice if needed.

The final notion presented in chapter 3 is the notion of tinkering. Again, the notion of tinkering as here described appears to align with the recommendations of the EEA, emphasising the principle of experimentation as a fundamental, transversal principle of governance in complexity. In academia, tinkering has been explored in a number of disciplines, including but not limited to education, sociology and psychology. It is an approach to problem-solving that emphasises creativity and exploration. It has been noted that a tinkerer may treat openness and contextuality as favourable conditions, as they provide more options and possibilities to come up with solution strategies.

Thus, what can conditions of epistemic complexity offer for problem-solving endeavours in the interface of environmental science and policy?

Due to the innate openness of epistemic complexity, problem-solving endeavours may be enriched with the advantage of freedom to explore, choose and create solutions. This would require, however, also the freedom to allow oneself to be wrong and to fail. It is at this point the institutional change is called for: we may recall how in the original exposition of wicked problems, the authors laconically included the feature that the planner (or decision maker) has no right to be wrong.

Taoist Epilogue: Ontological Complexity

Humans make *formalisations* of *nature*. Let's walk back to the tree.

Chapter 2 explored the difficulties of giving an exhaustive description of a tree. These difficulties have been said to lie in the task of deciding where to demarcate the tree from its surrounding. To this point, it is helpful to make yet some further distinctions. Namely between the domains of real-world things, one may call them empirical things, such as a physical tree standing in the forest; the formalizations that one may produces to describe that tree, as for example a complex system; and as a third domain, the knowledge one may gather about the tree, or the system.

In an instance where a person is unsure about the facts, they might experience the effects of epistemic complexity. In such an event, it can be useful to ask which of the domains specifically causes the perceived uncertainty. Arguably, what causes the unwanted effects of epistemological complexity is not the empirical thing as such, but the struggle to formalise the thing. In other words, how does one properly attest complexity to an empirical thing that exists outside of their formalisation? Is there an inherent complexity to a tree standing in the forest or is it more reasonable to speak of complexity in terms of the struggle to give a fully exhaustive description of it?

The mentioned questions are not to be equated to the phenomenological domain of asking about existence and truth. They are questions about empirical methodology and epistemological context. Since when practising scientific inquiry according to rational and modern standards, a scientist aims to obtain all information that is relevant for answering their research question, while factoring out all the information that is not relevant. It follows that, in order to meaningfully describe any complex system, a given research subject can not, as all evidence suggests, in all of its entirety and interrelatedness be formalised into a workable system. However to suggest a tree standing in the forest is radically open and contextual would arguably require some further argumentative strengthening. Since, as mentioned, a tree stands in various interrelations to many other systems such as the atmosphere and the soil. As these systems do themselves stand in various interrelations with other systems, following this pattern will soon include all of the planet and the universe. While it appears to be meaningful to imagine this structure of systems to be large and consisting of many parts, the things in it, as such, do not necessarily suggest complexity, if not formalised into a structure that can show features of complexity.

Radical openness and contextuality are in their definition attributes of formalizations, not things, as can be obtained from the respective research paper by Chu et al. (2003), where it is evident that the authors derived these essential features for complexity from models, as opposed to empirical objects. To therefore attest empirical objects, trees and their surroundings, any form of complexity is not evidently justified.

It may therefore be established that the tree standing in the forest and the system tree belong to two fundamentally different realms. The fundamental difference between the two realms however may lie somewhere close to the cause of radical openness.

It shall be argued that in an event where one would by some means successfully obtain every attribute and feature from said tree, their system would remain in its own distinct realm of abstractions. It would remain as a collection of fragmented information, but never become the tree itself.

It follows that there might be a quality to the tree that cannot be abstracted.

As any form of naming or defining is in itself an act of abstraction, it seems as if the non-abstractable quality of the tree pertains to a different realm. It may be that only by not-applying an epistemic framework, one might be able to access the exhaustive list of attributes. The philosophy of taoism has a central motto that says: “The tao that can be named is not the real tao”. (Laozi & Mitchell, 2006) Some Western scholars would perhaps prefer to read this principle in a different form, for example as “defining is confining”. I want to claim this principle to be the underlying root cause for the impossibility to describe the tree in its entirety.

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Abstract

Im Jahr 2024 haben sich Bemühungen zur Erreichung umweltpolitischer Ziele als unzureichend wirksam erwiesen. Im Kontext der Wissenschaftsphilosophie (POS) und der Science and Technology Studies (STS) wurde auf die komplexen Herausforderungen hingewiesen, wissenschaftliches Wissen in der öffentlichen Entscheidungsfindung anzuwenden. Ein dabei immer wieder genanntes Phänomen ist *epistemische Komplexität*. Diese wird in dieser Arbeit konkret definiert als die wahrgenommene Unvereinbarkeit einer Vielzahl von miteinander verbundenen, aber manchmal widersprüchlichen Wissensbeständen, die oft zu einem Zustand führt, in dem man unsicher ist, ob etwas vernünftigerweise als wahr bezeichnet werden kann. Durch die Erörterung einer Reihe von komplexitätsbezogenen Theorien aus POS und STS zielt diese Arbeit darauf ab, epistemische Komplexität als Zustand zu analysieren, welcher sich im Prozess der öffentlichen Entscheidungsfindung als nützlich erweisen kann. Die Arbeit kommt zu dem Schluss, dass epistemische Komplexität als Ressource betrachtet werden kann, die die Handlungsfähigkeit in Problemlösungsstrategien stärkt.