ENVIRONMENTAL RESEARCH AND GOVERNANCE IN THE DIGITAL AGE

Results of a horizon scanning for the environment department in tomorrow's society

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Abstract

Environmental research and governance in the digital age

In the project "Environmental Research and Governance in the Digital Age", a horizon scanning was conducted to identify and assess emerging digital changes with relevance for future environmental research and governance.

The scan report describes ten digital future topics, from digital earth technologies over digital money to digital statecraft, identifies the associated challenges and analyses their potential relevance for environmental research and governance. In addition, eight cross-cutting Emerging Issues are presented: digitally generated knowledge, digital literacy, changes in human-technology-environment relations, changes in human/actor relations, governance of digitalisation, governance through digitalisation, outreach of digitalisation and the twin transition.

In years to come, environmental research in the digital age needs to account for automated processes for accessing digital content, to reflect human and machine biases in digital environmental research, and to pursue new digital entry points and approaches to understanding and influencing the world with anticipatory consideration of its side-effects. Environmental research governance can use more agile and customized funding approaches in the future ("towards the need for change and the existing competences").

Foremost, environmental governance has the task of fathoming the reach and limits of digitalisation from its own perspective, evaluating them and introducing them into political processes in line with the guiding principle of digital humanism. The environment department (Umweltressort) has its own means for the targeted digitally supported formation of opinion and will, for engagement and participation and can combine these digital formats with established formats. In the future, environmental administrations will be able to provide actors with environmentally relevant data and algorithms in a more systematic and differentiated way for private, private-sector and public-interest purposes.

This Horizon Scanning Report is the first monograph on environmental research and governance in the digital age. With the systematisation of the future topics and emerging issues, the tools are available to take up digitalisation topics in the environment department (Umweltressort) in a structured and effective way in the operative and strategic work. At the same time, there is a need for permanent monitoring and productive uptake of emerging digitalisation issues that can be identified, captured and assessed in horizon-scanning processes.

1

Introduction

1 Introduction

Horizon scanning was conducted as part of the "Environmental Research and Governance in the Digital Age" project to identify the emerging digital changes on the horizon relevant to environmental research and governance and condense them into overarching future topics for the environment department.

The following questions guided the horizon-scanning process and the derivation of potential courses of action:

- Which new concrete digital developments are influencing how environmental research and governance are conducted?
- Which new digital future topics can and should the environment department put on its agenda, and what implications do these have for environmental research and governance?
- How can the environment department use digital future topics to shape environmental research and governance in practice?

This section will explain why environmental research and governance are evolving and may continue to change dramatically in the digital age. In this context, this section also explains the horizon-scanning process and outlines the structure of the horizon-scanning report.

1.1 Environmental Research and Governance in the Digital Age

The progression of digitalisation in our living environment shows no signs of slowing down. The smartphone has become our constant companion in our daily lives, and an increasingly amount of our communication in private, public and professional settings is performed digitally. When we want to know something, we converse with chatbots as if they are all-knowing human beings. We schedule appointments with authorities online, work from home on computers, and meander around on social media platforms like Instagram or TikTok. We are amazed at how successfully the advertising on our screens and in our digital mailboxes caters to our consumption preferences. The Facebook we know and love is set to evolve into a metaverse in which we can work, play, consume, or simply exist.

We are still surrounded by digital technology, even if we put our smartphones down or turn off our laptops. Smart home technology, with its network of sensors and actuators, keeps us feeling comfortable at home. If we disassembled our car, we would find a plethora of digitally networked components, such as displays, stepper motors and engine electronics. Even beyond day-to-day living, digital technology permeates practically every aspect of modern existence, whether it is the manufacturing of our consumer goods, environmental research or work in government administrations.

Digitalisation is a megatrend that is ever-present, often invisible and pushed by powerful companies such as Google (USA), Alibaba (China) and SAP (Germany), and governments all over the world. The benefits of digitalisation for individuals and organisations, and the prospects for growth and wealth, dominate media depictions of digitalisation. Digitalisation risks, such as the power of digital technology companies, digital surveillance systems with facial recognition or security flaws in data handling, are seldom the subject of public debate. Nevertheless, the general public does not question digitalisation in and of itself. Thus, in the late-modern world, the dawning "digital age", digitalisation is becoming an unquestioned, external boundary condition that must be understood, moulded, and used for effective action.

In recent years, digitalisation has been a primary driver of techno-social change (Bundesregierung 2018). Businesses, civil society organisations, research institutions, and governments are all seeking ways to leverage digitalisation to achieve their various goals and objectives. This creates an opportunity to reclaim positions of power and influence over regulations (Erdmann et al. 2022). The same applies to the relationship between digitalisation and environmental protection.

The German Advisory Council on Global Change (WBGU) describes digitalisation as an "accelerant for existing non-sustainable trends", but also as a potential lever and catalyst for the great transition in its flagship report titled *Towards Our Common Digital Future* (Messner et al. 2019). Digital interaction capabilities are promoting new institutional arrangements across government, private sector and civil society institutions to support a great transition. Current studies outline potential synergies between the digital and green transitions (Münch et al. 2022; Gotsch et al. 2020).

This dual digital and green transition (twin transition) requires new metrics and coordination of the action policy framework. With the "Digital Policy Agenda for the Environment", the environment department has created such a systematic framework for action.[1] The Agenda's goal is to make digitalisation more environmentally friendly. As reflected, for example, in the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) Artificial Intelligence (AI) Lighthouses funding initiative, the possibilities, limits and scope of digitalisation for environmental protection are becoming a concrete focus of research and innovation.[2] Digitalisation raises questions about its environmental effects, both in terms of opportunities and risks, but it also encompasses two additional critical fields of action that affect the environment department itself: environmental research and governance.

Environmental research and governance are key fields of action for sustainable development. Research – the systematic, transparent and verifiable development of new knowledge – and governance – governmental and non-governmental regulatory activity – are changing due to digitalisation. This is not only about the societal context's consequences of digitalising environmental research and governance, such as the environmental consequences of hardware production and operation, but also about how research and governance are practised in a society that is changing due to digitalisation.

Scenarios are used to predict long-term alternative development options. Future research and governance scenarios either treat digitalisation as an integral component of future developments[3] or specifically explore various digital futures[4]. But what actual evidence already exists that environmental research and governance are changing or must change as a result of digitalisation, or where is there potential for change?

Interdisciplinary and transdisciplinary research is increasingly exploring changes in human-technology-environment relationships and using them as a starting point for transformative research, with the digitalised society itself becoming the object of study. Digital priorities are set, and "intelligent" systems are touted as the key to sustainable transitions in research programmes across practically all research disciplines, including environmental research. Digital tooling in application-oriented (environmental) research (for example, CO_2 calculators, interactive graphics), big data and supercomputing for decoding genetics and simulating the climate, and digital knowledge ecosystems beyond established specialist publications are all examples of current research trends. Digitalisation initiatives, such as artificial intelligence or quantum computing, are being developed across departments and designated as future topics by governments. Digitalisation is also influencing changes in governance itself, including digital cooperation between authorities, the provision of digital identities to citizens, and the testing of new digital governance models.

With the use of digital technology, research programmes and projects are organised, executed, and utilised differently than they would be otherwise. For instance, text mining, or extracting useful data from massive digital text inventories, improves the process of determining the current status of research on a given environmental topic. Digital consultation formats allow for the inclusion of a greater and more diverse range of ideas in the agenda-setting of environmental research programmes than would otherwise be possible.

1 Digital Agenda | BMUV
2 Our "AI Lighthouses for the Environment, Climate, Nature and Resources" funding initiative | BMUV
3 cf. for research: Erdmann und Schirrmeister (2016), cited below, and for governance: Rosa et al. (2021)
4 cf. for research: Hessels et al. (2021), cited below, and for governance: Opiela et al. (2019)

Environmental governance is also using the expanding capabilities of digital technology, for monitoring compliance with environmental laws, for example. The environment department has already embraced some opportunities for digital development, including in the "Testing and implementing machine learning methods in the UBA's specialist procedures" and "Thinking ahead in e-government – strategy and testing for future government administration action in environmental policy after 2023, including process design for the German Environment Agency's medium-term organisational development (UBA digitalis)" research projects.

Thus, environmental research and governance are evolving in the digital age and may prove to be a crucial factor in the great transition. The "Environmental research and governance in the digital age" project aims.

1.2 Horizon Scanning

Horizon scanning was conducted as part of the "Environmental Research and Governance in the Digital Age" project to identify emerging changes relevant to environmental research and governance and condense them into overarching future topics for the environment department. Issues of strategic importance are identified during the horizon-scanning process, and potential in-depth studies are initiated. This horizon-scanning report is the first monograph on environmental research and governance in the digital age.

Horizon scanning is a strategic foresight method that aims to identify signals of change that, due to their potential future manifestations, are relevant for formulating current objectives, making strategic decisions and designing measures (Cuhls et al. 2015). Horizon scanning typically involves systematically searching for and processing signals of events, developments and topics. These signals can be weak, strong, hidden or known. The primary goal of horizon scanning is to detect weak signals early (for example, the emergence of new ownership models) and reveal hidden signals (e.g. a previously unknown social divide). The horizon-scanning process groups together several such signals for trends,[5] events and challenges into future topics with potential impacts, opportunities and risks.

Horizon scanning is employed in the "Environmental Research and Governance in the Digital Age" project to look for changes brought about by digitalisation (cf. the more detailed description of the methodology in Appendix A).

The following two questions were of particular interest:

1. What are the emerging digital developments and trends in (environmental) research and (environmental) governance?

2. How is digitalisation transforming the environment department's societal context, and what impact could this have on future environmental research and governance?

This particular horizon-scanning procedure is topic-specific and designed to identify, analyse, and evaluate developments in this context only, as opposed to the environment department's (Jetzke et al. 2021) open-topic horizon scanning, which searches for new developments and topics that may be relevant from a broader environmental perspective. However, the structured search for signals of change in environmental research and governance in the digital age extends far beyond the traditional confines of the environmental sector.

The search for signals was structured using both higher-level research dimensions and more specific scan fields.

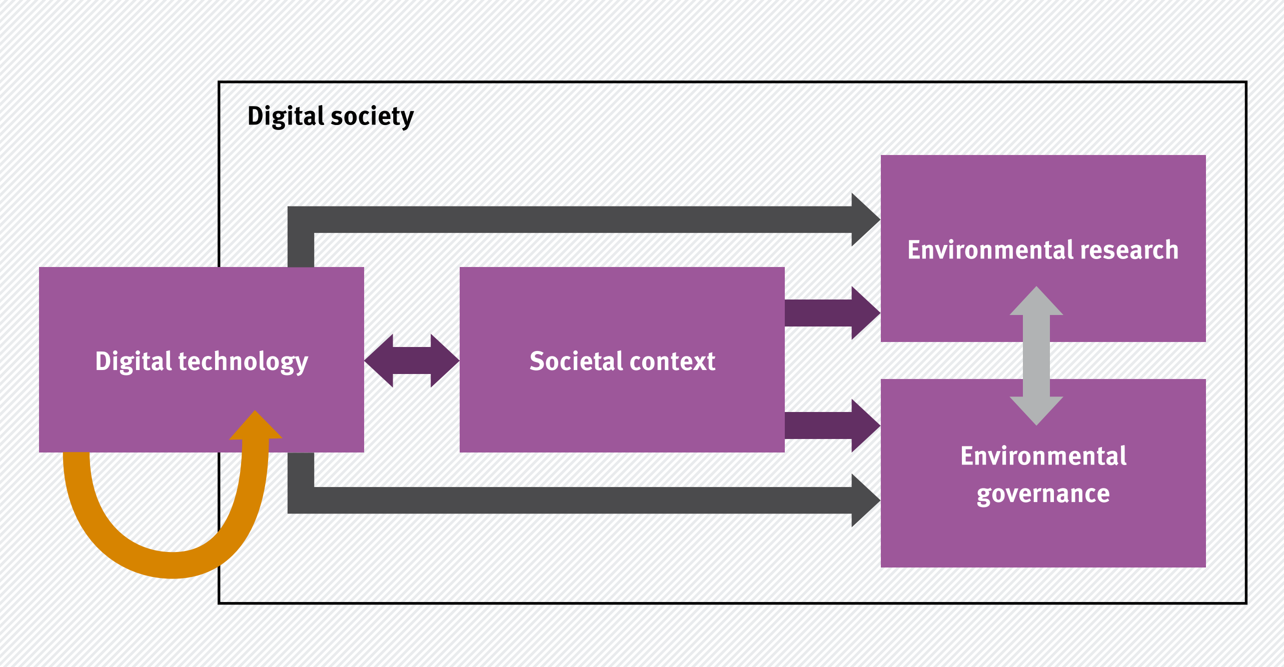
The fundamental relationships between the four main dimensions of digitalisation, environmental research, environmental governance and the societal context of environmental research and governance are illustrated in Figure 01 and then explained.

Digitalisation's potential to radically change environmental research and governance is the primary topic of interest. At the same time, digitalisation can have a direct impact on (environmental) governance

5 If signals for developments stabilise over time, they can establish a medium to long-term trend (e.g. deep fake on the internet) or a megatrend (e.g. digitalisation).

Figure 01

The four horizon scanning research dimensions



Notes: the grey arrows represent the direct effects of digitalisation on environmental research and governance, the purple arrows represent the indirect effects of digitalisation on environmental research and governance, the orange arrow represents a change in digitalisation itself, and the light grey arrow represents evidence production and expectation between environmental research and governance.

Source: Fraunhofer ISI

and (environmental) research or an indirect impact through the digitalisation of the societal context of environmental governance and environmental research (in other words, of the economy and society, for example). Digitalisation is ingrained in society and is prone to change itself (including quantum computing and interfacing with biotechnologies).

The following scan fields system forms the basis for the signal search (Figure 02).

Digital technology is presented as a separate scanning field to account for the change within digital technology itself.

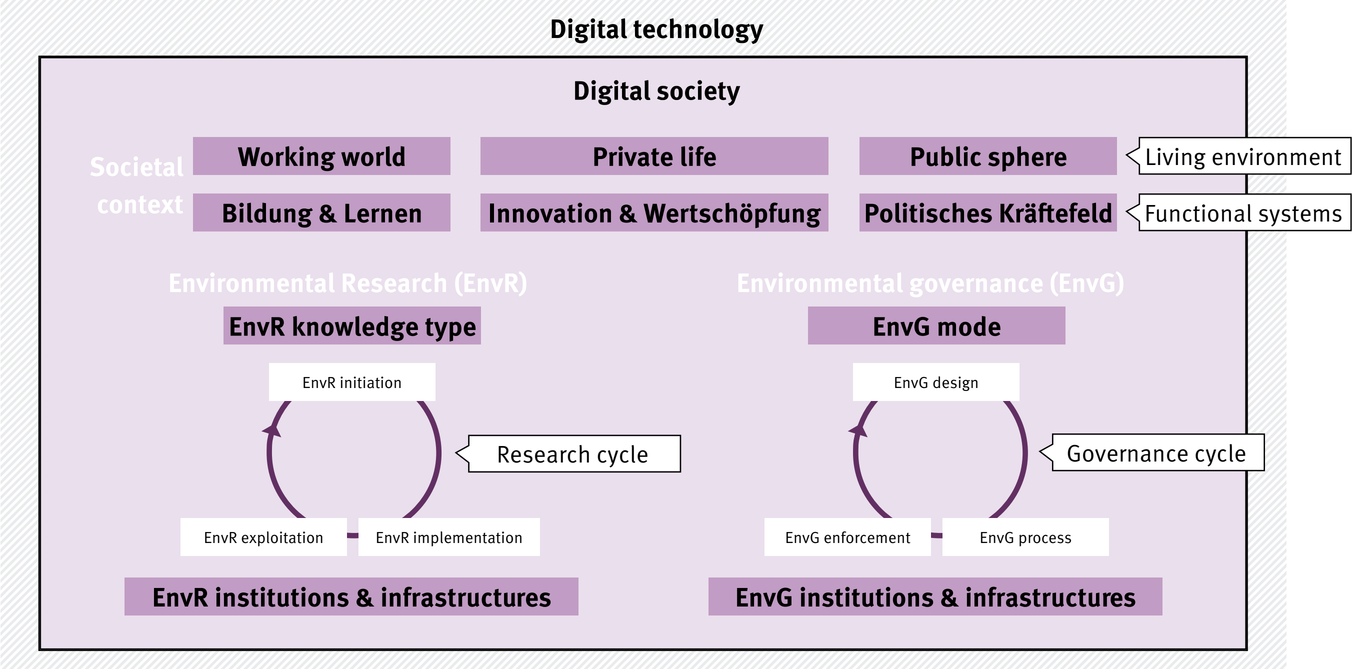
The societal context includes the living environment (working world, private life, public sphere) and the societal functional systems (education & learning, innovation & value creation, political sphere of influence) that are regarded as priorities for environmental research and governance and are changing as a result of digitalisation.

A similar system is used to organise the scanning fields for environmental research and governance. Environmental research is first recorded using a scanning field that requests the knowledge type (e.g. data-based evidence). Environmental research focuses on the research cycle, from inception and implementation to exploitation, at both the research programme (e.g. agenda setting, programme administration, programme evaluation) and research project levels. The research cycle and knowledge type are based on a long-term and solid foundation, which includes research institutions and infrastructures (e.g. research data ecosystems).

Environmental governance is captured in a similar fashion to environmental research. Environmental governance is initially qualitatively characterised using a scanning field that asks about the policy mode (e.g. reflexive, demand-driven governance). At both the policy level (e.g. policy negotiation, legislation, and operational implementation) and the government administration level, environmental governance is concerned with the policy cycle from the design and process to implementation. Long-term and stable foundations, governance institutions and

Figure 02

The 20 horizon-scanning fields



Notes: Each box represents a scanning field. EnvR – Environmental research, EnvG – Environmental governance

Source: Fraunhofer ISI

infrastructures (e.g. digital tax systems) underpin the policy cycle and policy type.

A total of 69 signals for digital change were identified across these 20 scanning fields during the horizon scanning through (partially) automated scanning, primary and secondary source analysis, exploratory future interviews and a validating internet search (cf. the more detailed description of the methodology in Appendix A).

Some signals cause changes in multiple dimensions, such as digital technology, digital society (societal context), environmental research and environmental governance, and cannot be clearly assigned to a particular dimension.[6] To simplify things, each signal, together with its short name, is then assigned to the dimension[7] expected to undergo the most change (cf. Figure 03).

Appendix B contains a table showing the 69 signals.

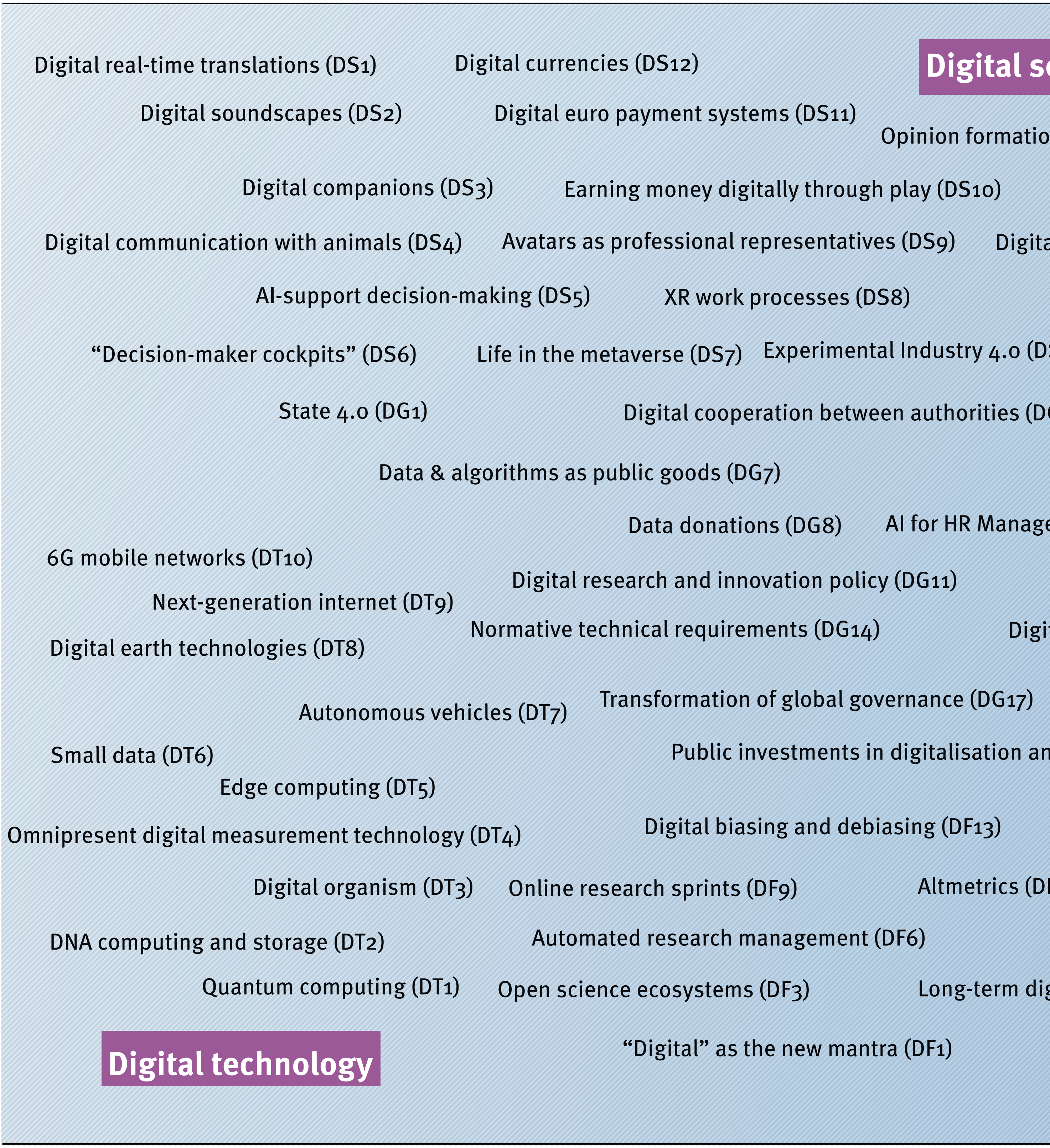
Each of the 69 signals of change in environmental research and governance due to digitalisation is supported by multiple sources and accompanied by a brief description. The signals were linked together to develop proposals for future topics in an interactive clustering workshop with participants from the environment department (cf. Appendix C2). Ten future topics with their related emerging issues for environmental research and governance, as well as from foresight in the digital age were examined in another future workshop with a larger number of participants from research and governance (cf. Appendix C3). This report focuses on these ten future topics.

Figure 04 shows the scanning process from the basic source population and signal candidates to the final formulated signals and the future topics derived from them.

6 For example, basic technologies such as quantum technologies can be used in an application context such as weather forecasts, and environmental research can be a component of evidence-based environmental governance.
7 Some of the signal titles have been modified slightly for this report compared to their use in the horizon-scanning process to extend the context of use of the signals from the environmental sector to other sectors.

Figure 03

69 signals from the horizon scanning

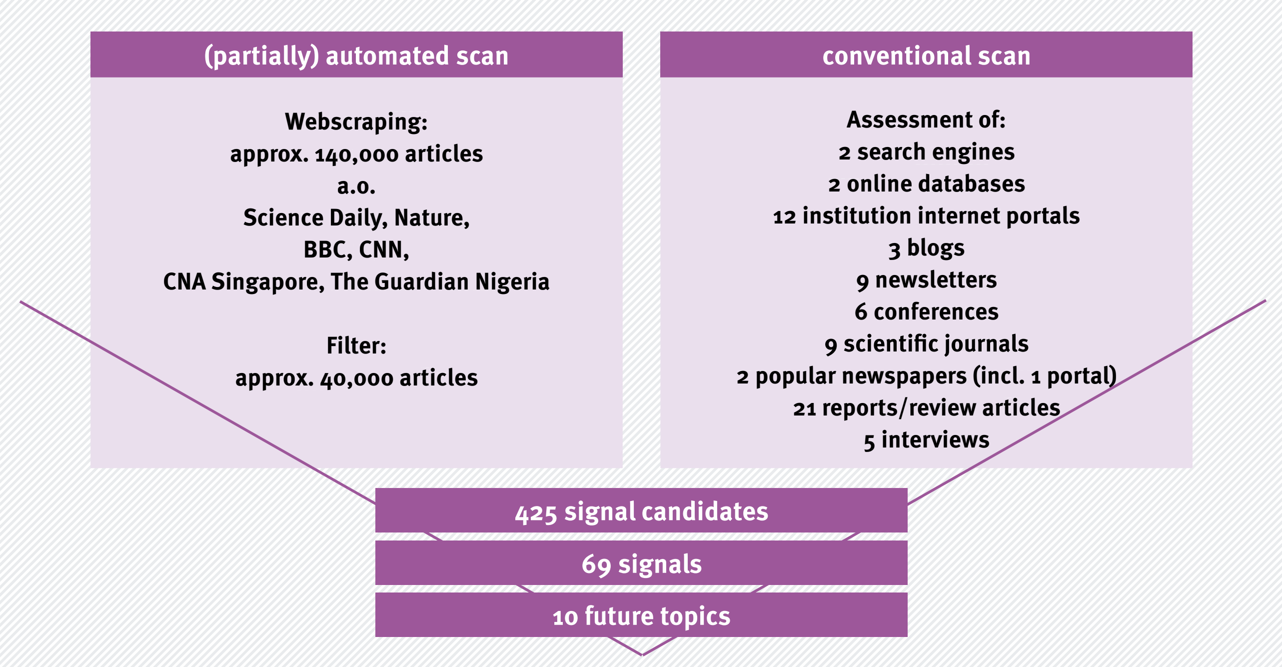


Notes: The four dimensions of digital technology, digital society, environmental governance and environmental research all intersect. The white background represents the signals for the main focus of the research interest, environmental research and governance, and the blue represents the technical and social environment.

Source: Fraunhofer ISI

Figure 04

The horizon-scanning process



Notes: The web scraping and filtering were performed twice. The web scraping and filtering figures only relate to the first period, so they represent a lower value.

Source: Fraunhofer ISI

1.3 The scan report

The scan report is intended for the interested expert audience. The findings are not only useful for the environment department and the stakeholders at the federal level that work closely with it. Many of the digital developments and topics presented can also help other stakeholders in research (e.g. research funding, research institutes, transformative research) and governance (e.g. federal states, municipalities, NGOs, IT companies, citizens) reconsider their respective areas of responsibility in the context of digitalisation and readjust their activities.

The scan report was prepared mainly in the second half of 2022. The actual horizon scanning was conducted within a specific prior time period. The change signals were primarily identified from March to July 2021. The sense-making workshop took place in September 2021, and the future workshop in January 2022. In the period from spring 2021 to summer 2022, a new federal government was elected, the Russian army attacked Ukraine and continues to do so to this day, and new signals emerged for changes in digitalisation and environmental research and governance. Current developments have been selectively included in this report where relevant to the topic.

The “Environmental Research and Governance in the Digital Age” project time frame includes other research projects that are closely related to the topic. Notable among these are the environment department-funded CO:DINA[8] project and various foresight activities by Fraunhofer ISI, especially Foresight on Demand: Ecosystem Performance on behalf of the European Commission (Directorate-General for Research and Innovation – DG RTD)[9] and the European Topic Centre for Sustainability Transitions (ETC-ST) on behalf of the European Environment Agency (EEA)[10]. Preliminary findings from these projects have been included in this report when appropriate, despite the fact that they have not yet been published.

8 Research – CO:DINA (codina-transformation.de) Research topics: Social-ecological statecraft, digital sovereignty and sustainability, system design for sustainable digitalisation, transparent value chains, digitalisation and growth (in)dependence, and sustainable public services.
9 S&T&I 2050 | Futures4Europe.
10 ETC Sustainability Transitions (ETC ST) — Eionet Portal (europa.eu).

We believe the project's main structural results are current and they are expected to remain so for some time.

The scan report is structured as follows:

- Section 2 details the ten future topics and their respective emerging issues from the horizon-scanning process.
- Section 3 examines the issues of environmental research and governance in the digital age.

The appendices supplement this report with more detailed information for anyone interested in learning more about the horizon scanning (Appendix A), the 69 signals (Appendix B) and the people involved (Appendix C).

2

Future topics

2 Future topics

Future topics combine several interconnected digital developments into a single broader topic. These future topics, their subtopics respectively, are new to the environment department and relevant in terms of how environmental research and governance will be practised in future in the digital age.

The scope and detail of the future topics are the product of multiple interactive workshops with participants from the environment department and other external institutions (cf. Appendix C). They reflect the perspectives of the parties consulted, the expert advisors and the authors on environmental research and governance in the digital age.

The future topics are inextricably linked, but they represent multiple alternative approaches to environmental research and governance in the digital age. Some topics are explored more from the perspective of digitalisation (digital technology and digital society), while others are examined more from a research or governance perspective. The interrelated nature of the topics is not surprising given the pervasive, omnipresent and interconnected nature of digital technologies.

The ten future topics are presented one by one:

The ten future topics

Starting with the overarching future topic of "The Digitalisation Paradigm", which acknowledges and critically questions digitalisation as the driving force of the late-modern society. Emerging debates regarding the scope of digitalisation and its potential design directions are outlined. The fields of environmental research and governance will also need to adopt a position in this respect.

After that, the next three future topics focus on the digitalisation of the world with direct references to environmental protection: "Digital Earth Technologies", "Digital Everyday Environments", and "The Next-Generation Internet". Environmental research and governance must take changing information and behavioural regimes into account.

In democracies, state power is divided between the legislative, executive and judicial branches. The three future topics, "Digital Statecraft", "Automated Government Administration Processes", and "Legal Tech", are concerned with the evolving relationship between citizens and state institutions. "Digital Statecraft" deals with the participation of citizens in the political process, particularly through CrowdLaw (legislative). The "Automated Government Administration Processes" future topic focuses on digital developments in the execution of the law (executive), and "Legal Tech" is concerned with digital technologies in adjudication (judiciary).

The "Digital Money" and "Digital Commons" future topics examine the conflict between private sector and public interests. Although negotiating the public and private appears unrelated to environmental research and governance, it is a key driver of how research and governance practices evolve.

To a certain extent, the future topic of "Digital Evidence" is interdisciplinary in that it explores the emerging data economy and culture in research and governance, including algorithms and tools, within the context of the nature of knowledge and the role of digital evidence in policy decisions.

Each future topic has a title and is described consistently. It is started with a short profile for the fast reader. The subject matter and scope of the investigation are explained first, followed by three sub-sections:

- Drivers and trends: which drivers give rise to the future topic, and which trends can be observed that characterise it?

- Emerging issues: which new topics and issues are emerging and gaining prominence for this future topic?[11]

- Possible environmental research and governance tasks: what might the emerging issues mean in practice for the environment department's environmental research and governance?

Finally, section 3 sets out a synthesis of the emerging issues and possible environmental research and governance tasks across all ten future topics.

11 Privacy, cybersecurity and interoperability are among the well-known issues associated with digitalisation. These general topics are only mentioned if they play an important role in a specific future topic.

2.1 The Digitalisation Paradigm – digitalisation as the driving force of late-modern society

Trend: digitalisation is penetrating deeper and deeper into an increasing number of areas of society, driving the development of late-modern societies, including their environmental research and governance.

Emerging issues:
- Changing human-technology-environment relationships in the digital age
- The scope and limits of digitalisation from the perspective of digital humanism and the social environment
- The twin transition as a design brief

In brief:

- Developments in digital technology and digital society are closely linked. In late-modern societies, the digital progress narratives are so powerful that people talk about a digitalisation paradigm. Environmental research and governance are no exception. They are also following the digitalisation paradigm.

- Digital technology has become an omni present, recognised and active agent in the world. However, the guiding principle of digital humanism strives to place humans at the centre of its activity and ensure that digital logics are subservient to humans. A guiding principle for a “digital social environmental protection” could also be developed in a similar manner. The social environment comprises the living and non-living things surrounding human beings, including nature infused with digital elements, but unlike the physical environment, it emphasises humans’ reliance on their social environment.

- It specifically addresses the extent and boundaries of digitalisation from an environmental perspective, including for environmental research and governance. The twin transition, consisting of the double digital and sustainable transitions, lays the groundwork for a systematic and functional overhaul of the environment department’s work.

Background: what it’s all about
Digital technology has permeated virtually all aspects of society, including education, research, business and politics, the living environment of humans, including

their private and public realms, and the human-altered physical environment in the Anthropocene.

When it comes to modernisation, growth, wealth and, to some extent, environmental protection, digitalisation is a prominent subject in many countries around the world, including Germany. Although digitalisation, with its opportunities and risks, is sometimes criticised, it is seldom called into question. Digitalisation is accepted, welcomed or promoted as an almost inevitable development. The omnipresence of digitalisation has such an effect that it eerily takes control of our lives.

Digitalisation is portrayed as a megatrend, a compelling narrative, a mission statement, a paradigm and a strategic task, among other things. The reality of digitalisation, and the discussion surrounding it, have the capacity to "reformat" the whole of society, including its core subsystems and aspects of life (like capitalism or Christianity before, for example). The current public debate frequently neglects the overall challenges of digitalisation. This section will focus on better highlighting digitalisation as a driving force for late modernity in environmental research and governance. As a result, the analysis depth for this first future topic will be greater than that for the subsequent future topics.

Drivers and trends

The progression of digitalisation is a dynamic interplay between technical development and socially relevant applications. Technical drivers include the miniaturisation and embedding of digital technology, greater functionality, higher computing power, the development of application-specific algorithms and software and the networking of digital components. Examples of current technological trends include quantum computing, big data, artificial intelligence, the Internet of Everything, extended reality (augmented, virtual and mixed), autonomous systems, 5th and 6th generation (5G and 6G) mobile telephony and cybersecurity.

In late-modern society, technical trends and drivers alone are not sufficient to push people toward digitalisation. Instead, this requires demand for efficient applications, complexity management, digital companions or the playful handling of information and opportunities for interaction that digital services can meet. Digital technology capabilities are intertwined with personal growth and organisational and social development possibilities to construct a progress narrative. This narrative's widespread dissemination and promotion is creating a generally successful digitalisation paradigm that is also permeating research and governance.

Digitalisation is a springboard for social stakeholders to rethink traditional power dynamics and shape policy (Erdmann et al. 2022). Digitalisation also detects fundamental patterns of predictable human interaction, such as the prevalence of the particular (Reckwitz 2020) – in other words, the never-ending search for the unique, the authentic, individuality – or global economic activities (Nassehi 2015), reinforcing social changes.

Emerging issues

As digitalisation spreads further and deeper into society, fundamental questions arise concerning the make-up of the late-modern society. Environmental research and governance will have to face significant changes and new requirements for shaping once again in the coming years as the digital age matures.

Changing human-technology-environment relationships in the digital age

Life is becoming more "artificial" as a result of the digitalisation of society.[12] The perception of the natural and anthropogenic living environment, traditionally conveyed solely through the human senses, is increasingly relayed through media or replaced by purely digitally generated stimulus-response models. Digital artefacts appear to act independently, leading people to regard them as real people. These include media representations of realities in life hacks, fiction, facts or deep fakes, and avatars of living or deceased people. These digital companions are increasingly displaying external human-like features and behaviour. As a result, stronger human-machine relationships are formed, which can either reduce or increase feelings of loneliness or togetherness.

"Natural artificiality" (Plessner 2003) in the age of digitalisation means that everyday actions are

12 cf. the overview in Erdmann et al. (2022) and a concise essay by Erdmann und Röß (2020) for more on this and other fundamental changes in human-technology-environment relationships

becoming more "environmentally oblivious" (Kahn 2011), and people only start to think about the environment again when the media reports a crisis or when they are presented with an idealised, unspoiled space (e.g. in wildlife films or fantasy). The digital living environment is, therefore, an independent living environment that reflects the natural and anthropogenic living environment while also having unique characteristics of its own. The "Digital Earth Technologies", "Digital Living Environment", and "Next Generation Internet" future topics will elaborate on more specific changes in human-technology-environment relationships.

For the purposes of digital humanism, new ethics are required as people increasingly immerse themselves in the digital realm and become emotionally and physically detached from the natural and anthropogenic living environment.

The scope and limits of digitalisation from the perspective of digital humanism and the social environment

In the age of digitalisation, the digital progress narrative peddled by industry associations, governments and environmental authorities[13] will always be critically questioned. Current social diagnoses, such as "digital surveillance capitalism" (Zuboff 2019) and "infocracy" (Han 2021), indicate significant shifts in how power is wielded in the digital age. Regardless of where you stand, the debate over digitalisation's potential and limitations as a social issue is only going to heat up. The guiding principle of digital humanism strives to place humans at the centre of the activity and ensure that digital logics are subservient to humans (Nida-Rümelin 2019). Similarly, the environment department could also develop a guiding principle for a "digital social environmental protection" that places the social environment at the centre of the activity and ensures that the digital logics of that social environment are subservient to humans. The term "social environment" comprises the living and non-living things surrounding human beings, including nature infused with digital elements, but, unlike the physical environment, it emphasises humans' reliance on their social environment.

Government environment departments will have to continually review their position as digitalisation becomes a social reality. Environment departments have a responsibility to weigh digitalisation, like other social realities, against their responsibility to protect the environment and promote sustainable transitions. What are the direct effects of digitalisation's hardware and applications on the environment? Which specific environmental issue is solved by which digital application? As other social realities demonstrate, this is by no means a trivial matter. The importance of these social realities for transitions is not reflected by the current recognition and addressing of the power of global financial stakeholders (Jakobs 2016) or the overwhelming defence by the middle class of their lifestyle (Blühdorn et al. 2020).

For effective environmental protection needs and to trigger dynamics for sustainability transitions, environment departments will increasingly need to address how digitalisation should be designed and

13 In its 2030 Strategy (Goal 4), the European Environment Agency (EEA) calls for welcoming digitalisation and making full use of its capabilities for environmental and climate protection (EEA 2021).

which areas should remain untouched by it from an environmental perspective (e.g. the experience of nature, nature reserves, etc.). At the same time, environment departments must prioritise the actual barriers to sustainability transitions, such as economic and political power, and consider what role digitalisation might play in overcoming these barriers.

The twin transition as a design brief

Social stakeholders are using digitalisation in various ways to further their own goals. For example, digitalisation is supposed to boost production efficiency, lowering costs and increasing companies' profits in the process. The digitalisation efficiency promises and the current business models of the leading digital platforms suggest that society will continue down its current, unsustainable path.

However, digitalisation can also serve as a means of navigating complexity, which is required within transition processes, for example, for essential social subsystems like energy, food, buildings and mobility. In light of the emerging digital paradigm, democratic countries are also attempting to harness digitalisation's productivity and capabilities for transition processes (Messner et al. 2019; Münch et al. 2022). The Joint Research Centre finds strong synergies between the green and digital transitions. For example, digital technologies could play a key role in achieving climate neutrality, reducing pollution and restoring biodiversity (Münch et al. 2022).

How the twin transition (the digital transition and green transition together) can be considered raises new theoretical and practical questions. Given the dominance and ambiguity of the digitalisation and sustainability agendas and the varying knowledge qualities, the question of interfaces, contradictory target systems and how to control the environmental impact of social metabolism within the digital paradigm arises. Additionally, there is the issue of analysing potential twin transition scenarios and determining the design scope for integrated digital environmental governance.

More people in the world now live under autocratic or dictatorial regimes than under democratic ones. Tech-heavy countries like China have created digital surveillance systems that are being tested, refined and optimised on a massive scale through the surveillance and control of minorities such as the Uyghurs. These technologies are also exported to other autocratic countries, such as Zimbabwe, to monitor and control (segments of) the population effectively. Digitalisation by the world's most powerful autocratic and dictatorial regimes and dictatorships is largely intended to enforce an autocratic style of rule. Autocratic nations like China are also adopting digitalisation to facilitate green transitions (for instance, in the form of newly constructed eco-cities), but they are counteracting these positive effects by significantly increasing their use of coal-fired power plants. Regarding the twin transition, the potential for countries with democratic systems to exert influence on countries with autocratic systems is generally limited.

Possible environmental research and governance tasks

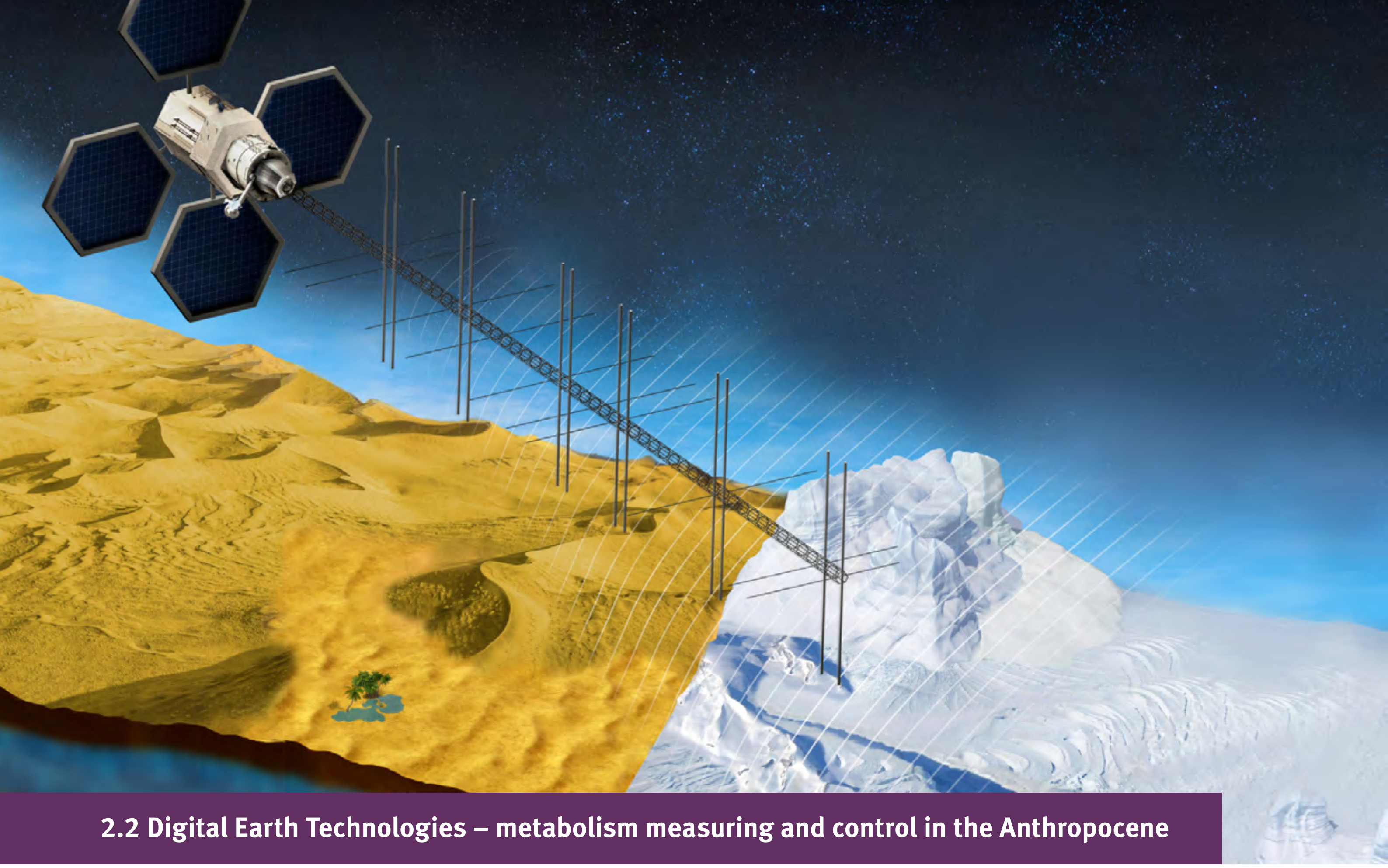
The emerging issues as a result of the digitalisation paradigm present new tasks for environmental research and governance:

- Human-technology-environment relationships are fundamentally changing due to digitalisation. The research programme must be systematically reviewed to assess whether its implicit assumptions about the nature of humans, their relationship with the environment, and their relationship with technology are deemed acceptable or require re-evaluation.

- The fundamental changes in the human-technology-environment relationships brought about by digitalisation provide a basis for deriving a design brief for environmental governance. Environmental governance must adapt to the different realities of life (e.g. remote work & education, digital companions), develop new environmental governance concepts and evaluate their effectiveness. In the Anthropocene, environmental governance must also consider how it can help identify aspects of life and work that should not be digitalised and develop an ethic of digital humanism.

- As a basic guiding principle, digitalisation and sustainability must be linked in a way that places a stronger emphasis on leveraging digitalisation in the service of sustainability. It would be necessary to rally both communities to negotiate a unified guiding principle at all levels of governance, including the global one, to accomplish this. In research programmes based on such guiding principles, interdisciplinary and transdisciplinary concomitant research and implication research of twin transitions, including model syntheses, integrated simulations, and foresight, take on a greater significance.

Environmental research is tasked with mapping the systemic ("net")-level environmental effects of digitalisation to lay the groundwork for its regulation through environmental governance. The digitalisation paradigm is driving the expansion of the data transmission infrastructure, including the transition from 4G to 5G and 6G. This advancement represents a significant leap forward for digitalisation. Methods for capturing specific impacts (such as innovative activities in the metaverse), developing future images for a sustainable digital society, and verifying future projections (such as whether or not there is evidence of certain scenario paths being chosen) all need improvement.



2.2 Digital Earth Technologies – metabolism measuring and control in the Anthropocene

Trend: New possibilities for measuring and controlling metabolism in the Anthropocene are emerging as digital earth technologies develop and spread.

Emerging issues:

- Knowledge to control metabolism in the Anthropocene
- Governance of digital earth technologies
- The scope and limitations of digital earth technologies

In brief:

- With the deployment of satellites with new remote sensing capabilities into Earth's orbit, the expansion of environmental observation on Earth, and the penetration of the man-made world with digitally networked measurement technology, the data situation is expanding to the point where detecting and controlling the metabolism on Earth appears feasible with this data.
- Various research groups are working on developing a digital twin of the Earth. This will be used to map the interconnection of natural metabolism with anthropogenic metabolism using data that is improving through digital measurement technology. If this is successful with sufficient accuracy, the effects of interventions could also be simulated and optimised under certain preconditions.
- The governance of digital earth technologies raises several issues, from financing the operation of remote sensing satellites and the governance of data from different sources to ensuring functionality and regulating access to Earth's digital twins.

Background: what it's all about

Digital earth technologies are used to record, simulate and control environmentally-relevant parameters across the planet. Digital earth technologies improve environmental monitoring by combining information and communication technologies (ICT), conventional monitoring technologies (e.g. remote sensing), and Internet of Things (IoT) applications (e.g. environmental sensor networks) (Bakker und Ritts 2018).

Terabytes of environmental data can be collected using digital earth technologies from terrestrial, aquatic, and atmospheric sensors, satellites, and monitoring devices based on a wide range of sources, including wearables, biotelemetric technologies for humans, animals, insects, and plants, (Ferrer 2022) and mobile sensors and apps. These data streams can be analysed, aggregated, and presented in real time using cloud-based internet systems (Bakker und Ritts 2018).

Social metabolism and natural metabolism models are combined to assess how changes in one system will affect the other. These Digital Earth Technologies have the potential to transform environmental governance drastically. Data, forecasting, real-time regulation, open-source and citizen science and measurement are some of the current main topics (Bakker und Ritts 2018).

Drivers and trends

Critical global challenges include climate change, biodiversity loss, natural disasters, migration, increasing geopolitical instability and security risks. Measuring data globally to achieve the United Nations Sustainable Development Goals is a massive undertaking. The widespread perception of environmental changes and dislocations, and the associated realisation that we live in the Anthropocene, are social drivers for digital earth technologies. Technical drivers include the penetration of nature with measurement technology and autonomous systems, the recording of an increasing number of parameters via remote sensing and earth observation, the creation of a digital twin of the Earth, and thriving space travel.

Information and communication technology with low-cost, increasingly powerful, and miniaturised environmental measurement technology is spreading everywhere – in smart cities, agriculture, and difficult-to-access areas with the help of locally installed and mobile sensors (e.g. drones) (ubiquitous sensing) (van Genderen et al. 2020). Information processing, increasingly designed by humans but integrated into nature, is leading to a convergence of digital technology and living organisms. The increasing computing power of computer systems, their more effective use via cloud and edge computing, the development of new assessment algorithms, and the use of artificial intelligence in data processing all play an important role in information retrieval (GISGeography 2022).

With its geostrategic goals and economic possibilities, the thriving space sector enables and inspires dual-use activities in space (e.g. military and environmental). This includes in the upstream sector, with, among other things, research and the construction of satellites and ground stations, and the downstream sector, with the provision of services and products for terrestrial use that rely on space-based data and services (ESA 2022). Geodata gathering via satellites has been practised for a long time, and simulation models of environmental phenomena have also been used for some time. New generations of satellites, which can be placed more inexpensively as space flight becomes more commercialised, also enable significantly higher-resolution images and the collection of new information through remote sensing[14].

However, technological capabilities are continually evolving, making entirely new applications possible. In particular, creating an accurate digital model of the Earth as a cohesive system is seen as the next major milestone being pursued by various stakeholders. For example, the European Commission's "Destination Earth" initiative, which aims to create such a digital twin of our planet within the next ten years, was given the green light in March 2022[15].

Emerging issues

Digital earth technologies are one of many elements involved in holistically mapping environmental change, capturing the human impact in the process, and thus initiating appropriate environmental protection measures to ensure compliance with planetary boundaries. However, this also presents challenges. These include comparing the role of digital earth technologies to other potentially more effective and resource-efficient environmental monitoring and protection measures. This goes hand in hand with the issue of priorities in terms of funding, skills development and ensuring the reliability and accuracy of the data collected. Similarly, questions about authority arise – who has access to and the authority to interpret the data? Who develops and implements appropriate strategies based on the data? Last but not least, digital earth technologies represent a shift in how we generate and apply environmental knowledge, with corresponding ramifications for other modes of knowledge acquisition.

14 Federal Ministry for Economic Affairs and Climate Action (BMWK) – German environmental satellite launched into space
15 Destination Earth – a new digital twin of the Earth (europa.eu)

Knowledge to control metabolism in the Anthropocene
A comprehensive digital image of the Earth based on global measurement data can replace traditional approaches that mainly focus on small-scale controlled systems and extrapolate results to create a new frame of reference for environmental research. Integrated simulations allow a better representation of the interactions but at the expense of comprehensibility in the calculations (black box). Uncertainty surrounds the extent to which such a paradigm shift could result in the loss of knowledge that is not outdated, increasing reliance on digital earth technologies. If these drivers and trends continue, the integrated simulation of social and natural metabolism may become realistic enough to be used to predict the impacts of interventions.

By linking socio-economic metabolism with the formerly natural systems phenomenologically, quantitatively, or causally, digital earth technologies have the potential to advance our understanding of human-environment relations in the Anthropocene dramatically. Using the digital twin as a basis for modelling introduces a certain technical rationality with repercussions for handling other forms of knowledge about the world. This applies to other types of knowledge that are important for cultural development (such as religion) and traditional empirical research methodologies that are challenged by an overarching digital image. Incorporating various sub-aspects into an overarching model can potentially yield results that are inconsistent with or even contradictory to previous research paradigms. The inherent epistemic opacity of simulation models, (Pedro 2021), meaning the inability to comprehend them fully, creates an area of conflict between different types of knowledge.

Environmental satellites are being equipped with sensors with a greater spatial and temporal resolution for an increasing number of parameters.[16] The knowledge generated by digital earth technologies can be

16 The EnMAP (Environmental Mapping and Analysis Program) environmental satellite orbits the Earth in a low orbit and simultaneously takes images of its surface in over 250 visible and infrared light sub-ranges. Every four days, a complete picture of the state of and changes in the Earth's surface is produced to support sustainable land use (for instance, EnMAP can be used to monitor the health of plants and water bodies), characterise climate change, and detect environmental degradation early in order to combat it. EnMAP is expected to reveal previously unknown phenomena (BMWK – German environmental satellite launched into space).

used not only for environmental protection, but also for environmentally destructive activities (Oliveira und Siqueira 2022). There is a general lack of imagination and conceptualisation of how digital earth technologies could effectively support transformative environmental governance and what framework conditions would be required to accomplish this.

When developing the necessary competences for creating, optimising, and using a digital twin, it is crucial to consider that other competences, particularly those related to traditional forms of knowledge generation, may be undervalued or even lost in the process. On the one hand, this may cause people to lose their sense of independence and mistrust the corresponding systems, especially in light of the digital divide. On the other, there is a growing reliance on digital systems.

Governance of digital earth technologies

Research, implementation, and maintenance of a coordinated set of digital earth technologies to measure and control metabolism in the Anthropocene, ranging from remote sensing satellites and sensors in the Internet of Things to a fully functional digital twin of our planet, continue to necessitate significant investments that are being made despite uncertain benefits and inaccessibility to other environmental protection strategies. Furthermore, the resources needed for the systems and their (digital) infrastructure in the form of materials, energy, and know-how must be considered (van Genderen et al. 2020).

Forward-thinking governance of digital earth technologies proactively addresses ethical issues and risks associated with the proliferation of these technologies. Who owns such a digital image of the Earth? How are access rights, interpretative authority and usage rights over data distributed? Although the data collected by digital earth technologies is initially value-neutral (considering data security, availability, and reliability), the same cannot be said for its interpretation and solution derivation. Different aspects must be weighed here to formulate an objective. Consequently, access to the systems and transparency in their use become questions of power. The complexity of the subject matter and the various ways of prioritising “desirable” developments can be used to justify adopting different approaches (Oliveira und Siqueira 2022). This can further undermine confidence in the informational value of digital earth technologies.

As the use of digital earth technologies grows, reliance on their functionality also increases. This raises the question of whether the necessary skills exist and whether the systems or the underlying infrastructure have the technical functionality, security and robustness to withstand manipulation attempts.

The scope and limitations of digital earth technologies

By their very nature, environmental research and governance have long been based on big data. As digital earth technologies become more prevalent, the vast amount of data generated places new requirements on potential users: which data sets exist (including environmental data and data from other areas and data collection forms), and how can they be used for the respective research and governance topics?

There are already numerous business models based on the data generated by digital earth technologies. Therefore, the further development and expansion of these technologies are linked to economic interests that may or may not be compatible with environmental and climate protection, such as the use of remote sensing data for more efficient exploitation of natural resources like wood. As a result, one challenge for environmental research and governance is to avoid raising false hopes regarding the capabilities of the technologies and to ensure that investments in research and the dissemination of digital earth technologies generate synergies between cost-effectiveness and sustainability, as opposed to being used for other purposes under the guise of sustainability.

The issue of dual use is becoming increasingly important, particularly in the field of digital earth technologies. The simultaneous occurrence of geostrategic power dynamics and global environmental crises poses a risk of military-strategic technologies being falsely presented as promoting environmental protection, a phenomenon known as “greenwashing”. This is observed, for example, in initiatives involving autonomous systems to explore previously inaccessible locations (such as the deep sea) (Erdmann et al., 2022). An analysis of the donors and research stakeholders reveals that the primary focus is not on the motives widely propagated in public, such as ecosystem research. Instead, tangible geostrategic, military, and commercial interests take precedence, often resulting in direct negative impacts on the ecosystems in question.

Digital earth technologies present the human-environment relationship through media. With the expansion of digital earth technologies for measuring and controlling metabolism in the Anthropocene and communication regarding their capabilities, large segments of the population will perceive the Earth as something that can be technologically controlled. This alters humanity's perspective from a fated existence on earth to a duty to shape things with specific responsibilities.

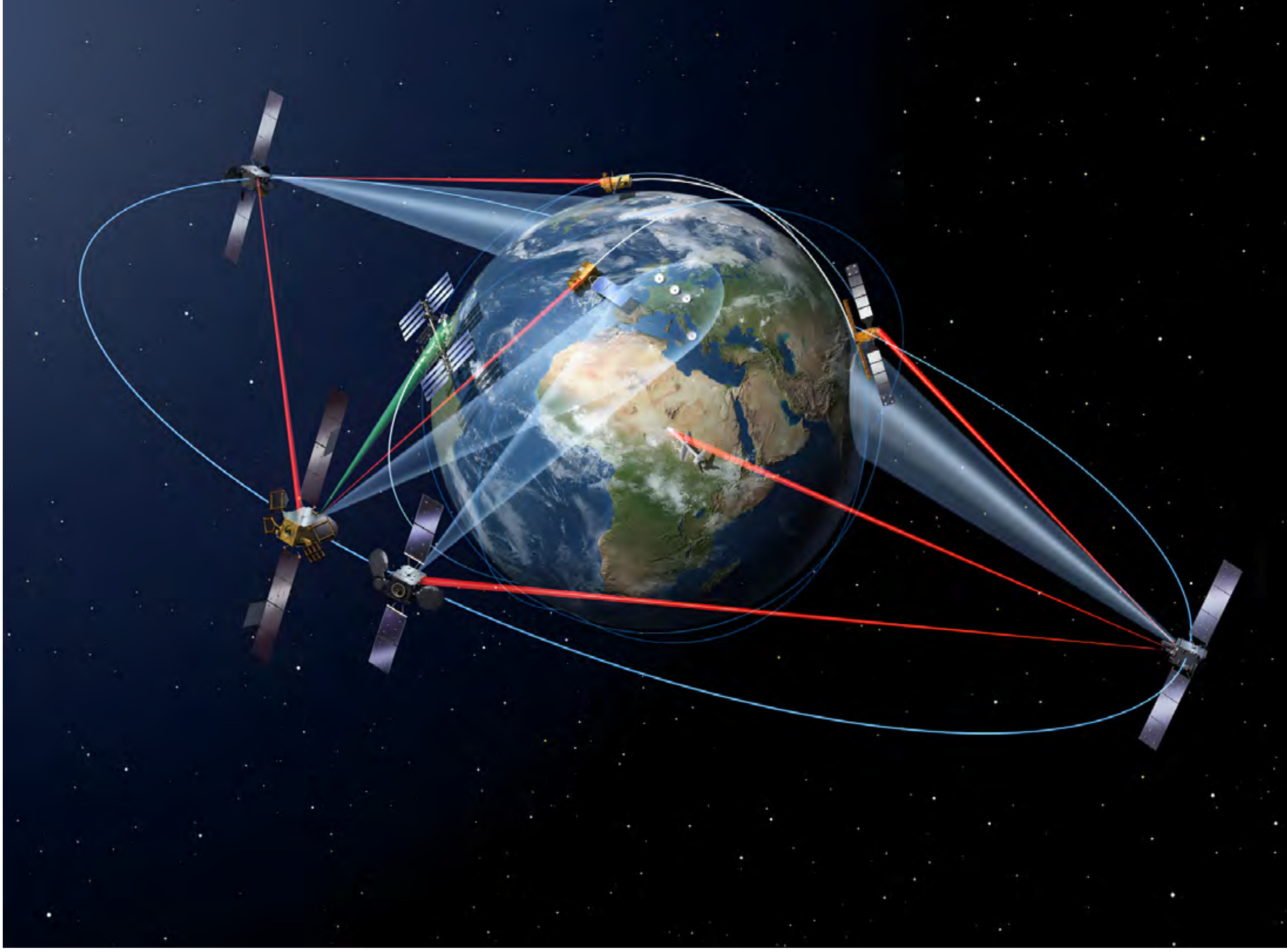
There is no expectation in the foreseeable future that digital earth technologies will be able to precisely measure the Earth and support the control of the metabolism in a manner that would lead to a string of success stories. Instead, it is envisaged that ignorance about metabolism will persist and that unforeseen events will repeatedly challenge faith in the early recognition and controllability of metabolism through digital earth technologies. Nonetheless, the promise of knowledge and control remains an appealing narrative for many. Therefore, in the future, ambivalent attitudes towards measuring and controlling the Earth's metabolism will likely be widespread.

Possible environmental research and governance tasks

Digital earth technologies hold considerable promise for observing and simulating natural material flows and, if necessary, influencing them for environmental and climate protection based on this knowledge. However, it is currently unclear whether these potentials can be fully realised and whether the required investments would be cost-effective compared to alternative strategies. The provision of data from Copernicus, the European Environment Agency's Earth monitoring programme, has drastically altered its mission profile and working methods.[17]

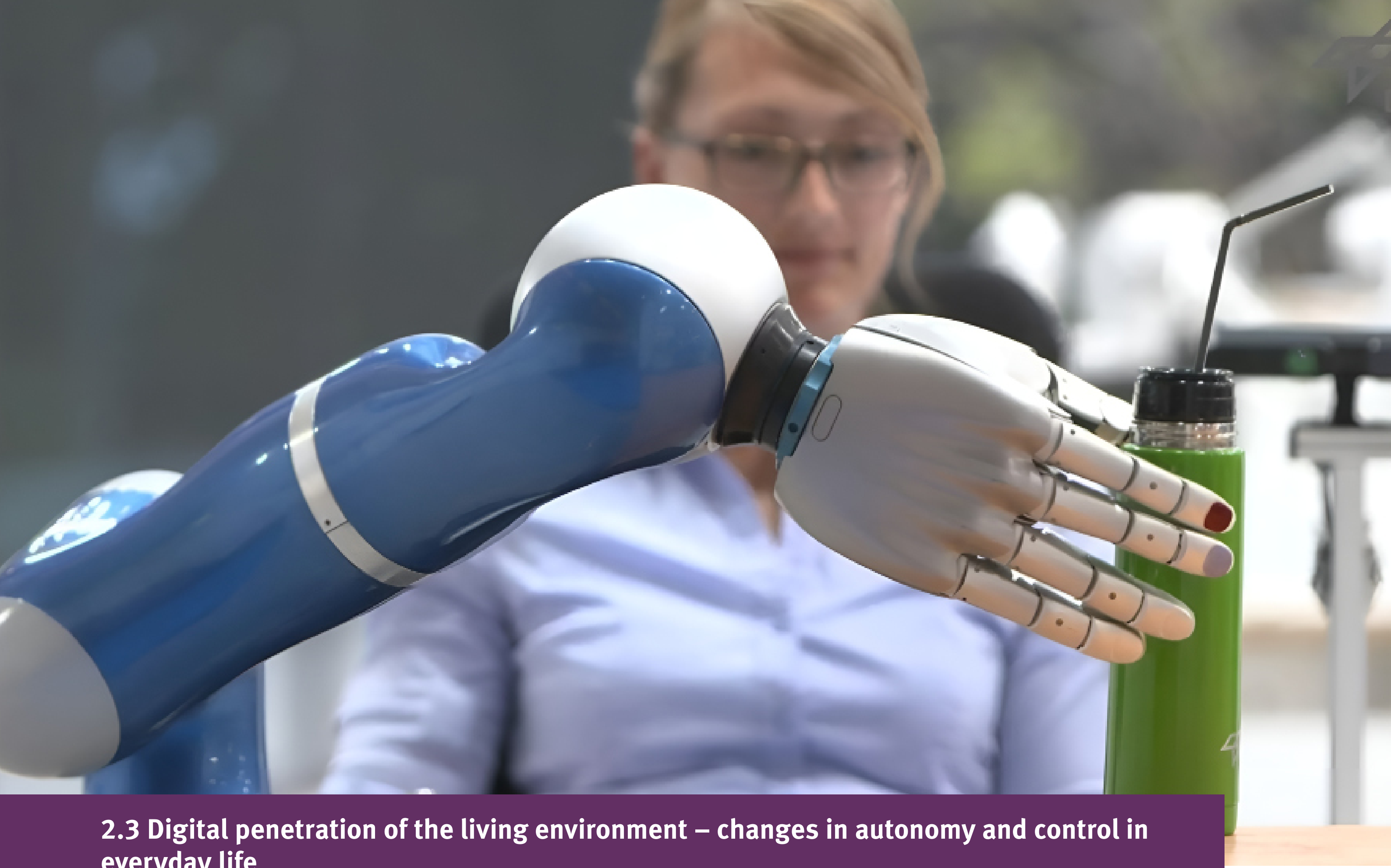
- Digital earth technologies have the potential to improve our understanding of human-technology-environment relationships profoundly, but their impact on other types of knowledge and environmental movements is unknown. Analytical tools use artificial intelligence (AI) and models to map environmental knowledge in innovative ways. Recognising animal emotions has the potential to revolutionise animal welfare, nature's productive power could be harnessed in new renewable ways, and the unexpected influences of human activities on the environment could put new environmental issues on the agenda. In light of this, it is imperative for environmental research to systematically enable these new avenues of information, placing greater emphasis on ethical issues and adopting an interdisciplinary approach.
- In this context, it will also be crucial in the future to continually review the potential of digital earth technologies in light of their constantly evolving (technical) capabilities and assess the promise of self-control and influence in relation to an anthropogenic metabolism within the limits of planetary boundaries. Specifically, it is necessary to evaluate the contribution of digital earth technologies to data collection and the measurement of sustainability indicators, particularly for countries with inefficient reporting.
- Not least due to the high energy demand of digital earth systems and the supporting infrastructure, it is vital to examine (environmental) cost-benefit factors and keep an eye on the "net contribution" to achieving sustainability goals compared to alternative strategies. Consideration must be given to the fact that the data collected by digital earth technologies is frequently used for purposes other than environmental and climate protection, such as military purposes (dual-use problem). Consequently, possible greenwashing of non-sustainable application areas must be identified and avoided.
- Concerning the financing of the systems, it is essential for environmental governance to create a synergy between cost-effectiveness, accessibility and transparency, security and resilience, and the long-term viability of the systems (governance of technology).
- Digital earth technologies result in changes in environmental governance, meaning all of the social stakeholders and institutions (norms, rules, standards, laws, customs, etc.) and the data collection and decision-making processes that in-

17 Copernicus – European Environment Agency (europa.eu)



form environmental decisions. Stakeholders such as the European Space Agency, sensor manufacturers, data centre operators, AI companies, internet regulators and environmental administrations establish a new global framework that far exceeds the scope and complexity of previous national and sectoral approaches to environmental monitoring and governance.

- The relationship between digital earth technologies and the associated understandings of governance in the context of transitions remains largely unexplored (governance by technology). There is a lack of understanding of the capabilities of digital twins of the Earth and impact assessments (e.g. how findings from different models can be merged in a focused and systematic manner to inform decision-making, “Confidence Approach”) and how to manage the associated uncertainties. Governance scenarios and concrete governance models that support automated data analysis and prediction (e.g. using machine learning) are also lacking.



2.3 Digital penetration of the living environment – changes in autonomy and control in everyday life

Trend: The penetration of digital technology into the everyday living environment

Emerging issues:

- Changing human-technology relationships in daily digital routines
- Digital everyday environments under the magnifying glass for environmental research
- Influencing behaviour in areas of conflict between competing interests
- Ability to perform digital tasks in everyday life
- Scope and limits of digital living environment penetration

In brief:

- Digital technology is increasingly becoming an integral part of our everyday living environment. This future topic is about the interaction with objects where digital technology operates in the background. These include interactions that serve a specific purpose (e.g. involving automated home technology), parasocial relationships (e.g. with anthropomorphic robots), and close-range proximity relationships (e.g. where chip implants are integrated into our bodies).
- People's relationships with technology are evolving as digital technology fades into the background. Specifically, as more and more tasks traditionally handled by people are delegated to digitalised technology, the techno-economic aspects of technology design are becoming more important at the expense of user autonomy. Challenges include new combinations of interests and changing skill sets.
- Establishing digital interfaces within the living environment can create an innovative entry point for observing, studying and influencing real-world everyday behaviour. In terms of environmental governance, the question arises as to what extent and under what conditions the option of technically mediated, pre-reflective behavioural impact is desirable and where it fits within the framework of all measures for more environmentally sound everyday behaviour.

Background: what it's all about

The living environment comprises the various environments we inhabit and navigate daily: our homes, means of transportation, streets, roads, spaces, schools, factories, offices, shops, government offices, leisure facilities, social gathering places, restaurants, our natural environment (cf. Section 2.2), and many others. In a broader sense, it also includes our clothing and our bodies. The terms pervasive computing, ubiquitous computing, and ambient intelligence have long been used to describe the extensive and widespread integration of computers into everyday life.

Digital technology either helps with routine activities and daily decision-making or takes them away from humans. Unlike the "next-generation internet" approach with the metaverse discussed in Section 2.4, this future topic focuses on integrating digital technology into objects that are not yet or only partially digitalised, digital companions and wearing computers in the body (implants) or on the body (wearables). In particular, this changes the relationship between autonomy and control in our everyday lives.

Smart car interior mirrors that tell us when we are getting tired via eye tracking, refrigerators that alert us when food is about to expire, and the "Alexa" that establishes not only functional but also emotional and parasocial relationships are all current examples of the digital penetration of the living environment. Smartwatches monitor our pulse and prompt us to change our physical activity. Transhumanists are a minority who advocate for digital enhancement or the artificial improvement of humans' capabilities beyond their natural limits. Many of them wear computer implants. This topic is examined from the perspective of environmental research and governance in light of these recent developments, with a focus on new emerging issues.

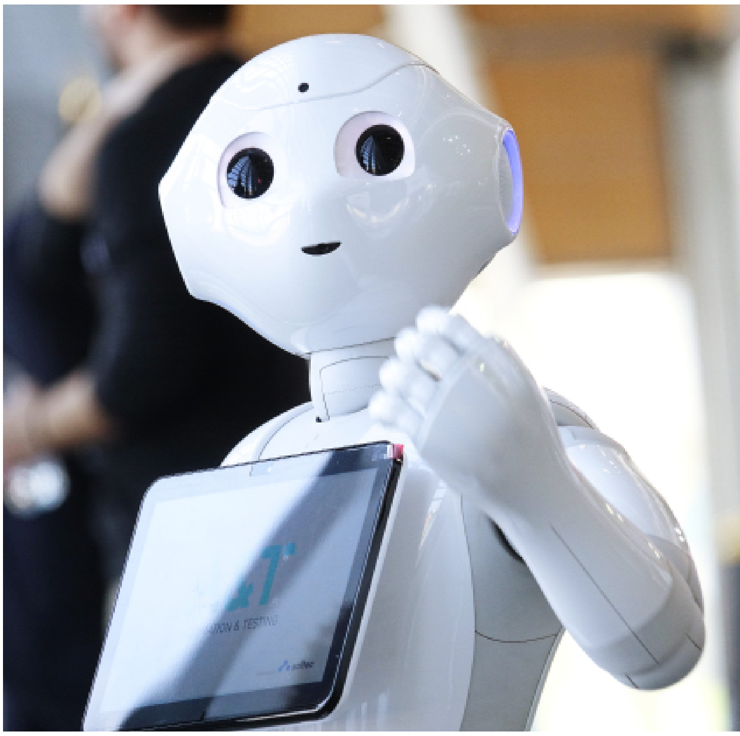
Drivers and trends

The main drivers behind the digital penetration of the living environment are the technical development of information technology, the decreasing cost of microelectronics, new business models, and the expanding market presence of commercial providers, plus social trends such as an actual or perceived lack of time (need to delegate), self-optimisation (need for improvement), and feelings of loneliness or unmet communication needs.

Miniaturisation and improved microelectronic performance are key technical drivers for the digital penetration of the living environment. By embedding microelectronics, particularly sensors and actuators (generating movement or deformation), into objects, an increasing number of systems are being developed that can autonomously perform tasks in everyday life. The networking of digital objects is creating an Internet of Things (IoT). Basic technologies such as artificial intelligence (AI) and edge computing form a computer architecture that brings data storage and computing processes closer to the data source and enables internet-connected decentralised data processing.

Research in soft robotics and affective computing is leading to the development of "digital companions". The quality of the interaction between people and technology in the background or as "cooperation partners" is expanding and altering. Thus visual, auditory, and occasionally haptic interactions occur (e.g. with robot-like devices), which sometimes develop into anthropomorphic, i.e. human-like, relationships.

Not only is digital technology permeating more objects and physical environments, it is also increasingly being worn by individuals (e.g. smart watches,



i-Clothes) and is already progressively entering human bodies, e.g. via implanted microchips or brain-computer interfaces. Here, computer, nano, bio and cognitive technologies all meet. These new technologies are also based on developments in cognitive science, neural research (such as the Human Brain Project), and artificial intelligence.

Emerging issues

The digital penetration of the living environment is progressing and, due to the emotional components that can be generated with increasing technical sophistication, is becoming more and more subtle and immersive. As the potential for using nudges to regulate behaviour is recognised, it takes on a new dimension in terms of its ability to influence everyday actions.

Changing human-technology relationships in daily digital routines

People interact with digital objects in their everyday lives with varying degrees of consciousness. The hallmark of daily routines is that they are typically not considered but carried out automatically. When it comes to the digital living environment, it makes sense to differentiate between three modes of interaction (Erdmann et al. 2022):

- Relationships with the "silent helpers" that serve a purpose. Computers are embedded in everyday objects, frequently networked with one another, intuitively controllable, or autonomously acting. People view these types of computers as useful. They make their daily lives easier and need little attention, so their users can devote their limited time to activities they value more than the tasks delegated to these computers (e.g. vacuuming, shopping, choosing music).

- Parasocial relationships with digital companions: with advances in the research fields of affective computing, natural language processing (NLP) and soft robotics, anthropomorphic computers are becoming increasingly commonplace in everyday life. By recognising and generating emotions, humans and computers can form parasocial relationships. Uncertainty surrounds the extent to which these parasocial relationships can supplement or replace interpersonal relationships, for example, to reduce feelings of loneliness. Examples of digital companions in daily life include chatbots like ChatGPT, robots acting as familiar human counterparts, and robots collaborating with humans in the workplace.

- Close-range proximity relationships with computers worn in or on the body ("fusion"). This includes a wide variety of technical artefacts that vary in (1) how closely and irreversibly they are fused with the human body, (2) whether they are intended to influence the physical, cognitive, or emotional characteristics and abilities of the human, and (3) whether the individual using the technical artefacts has personal control over their functions or if their activities are externally controlled.

While relationships with computers that serve a purpose are already a part of our daily existence and are being further consolidated by the Internet of Things, parasocial relationships with computers are a more recent phenomenon.

If citizens increasingly make or are nudged to make AI-supported decisions not only in front of the computer but also when interacting with their digital objects, this will affect their relationship with the living environment profoundly. The digital background assistants and digital life companions send signals and execute processes. Signals can serve the interests of multiple parties, including the recipient, the provider, business partners, and environmental protection, by influencing decisions related to environmental protection or facilitating environmental protection activities.

Digital aids can be seen as beneficial and supportive in daily life for certain recipients, providing assistance and relief. However, for others, they may be perceived as disempowering. By performing tasks that humans would otherwise perform, digital assistants reduce the need to think about routine actions unless feedback mechanisms are expressly provided. At the same time, the recipients' autonomy is maintained. For example, by displaying processed data from life cycle analyses or even through immersive augmented and virtual reality, it becomes possible to make the potential environmental impact of everyday behaviour more tangible. Reduced reflection on day-to-day behaviour and its connection to the environment can weaken the intrinsic motivation to align actions with normative standards such as environmental protection and the sense of personal responsibility. However, it can also provide relief if sustainability is established as a framework for all behaviour.

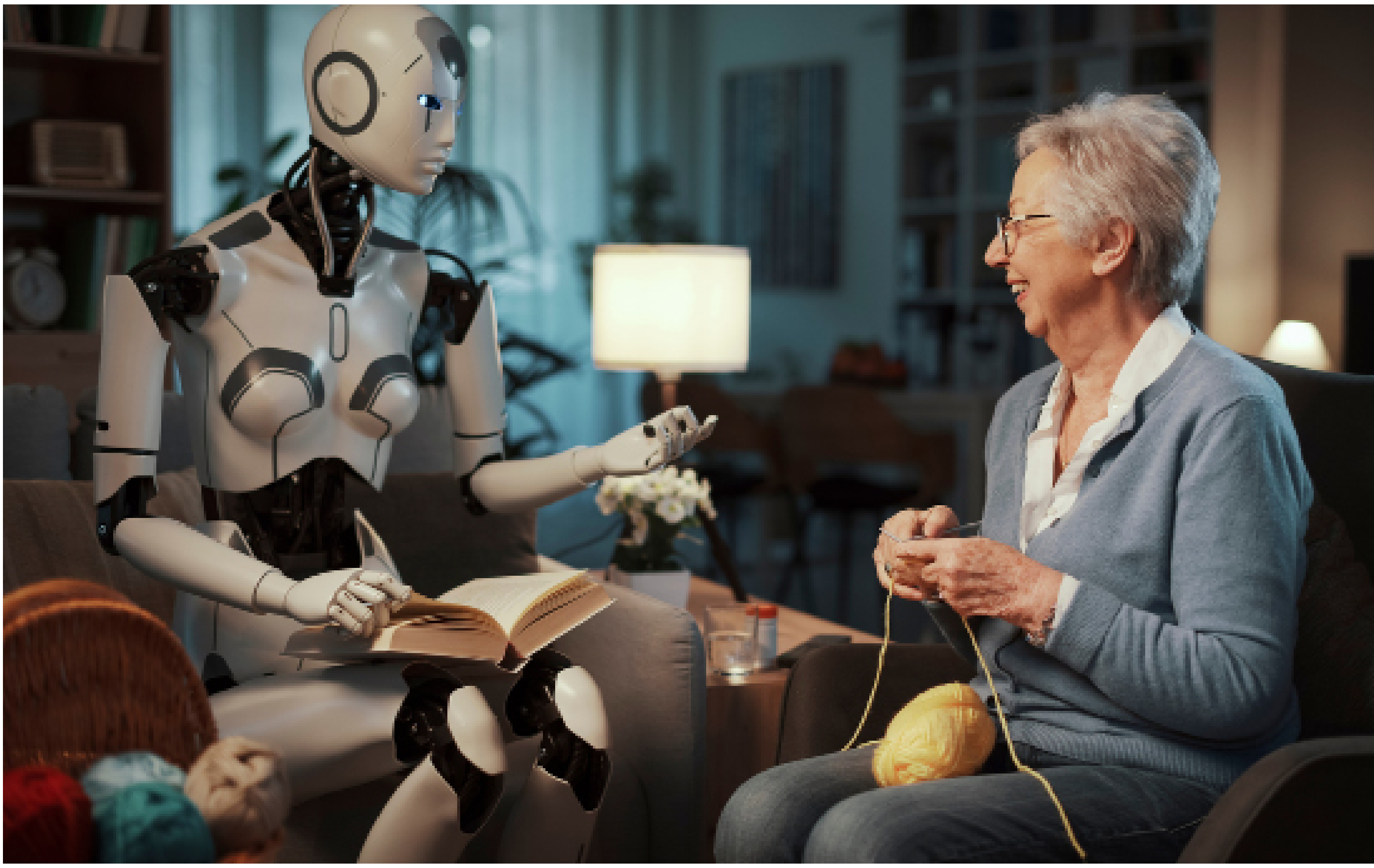
Digital assistants often only develop into digital companions through ongoing interaction in everyday life. Possessing humanoid characteristics and social behaviours, they tend to elicit anthropomorphic projections from users. The supplementation and replacement of human relationships with human-technology relationships have emotional consequences that affect everyday activities and associated resource consumption patterns. This includes the resources expended for digital companions and altered mobility patterns. However, digital companions can also serve as a new starting point for environmental communication and behaviour modification.

Human-computer interface technologies were originally developed and used for narrowly defined issues within specific regulated domains in specialist institutions, such as research, medicine, and rehabilitation. However, increasingly smaller, more powerful and portable devices with a growing range of functionality are enabling the use of these technologies for more and more purposes, including everyday use "for everyone" (Erdmann et al. 2022). Future cognitive enhancement or augmented cognition applications, in which predictive, advisory, and automated functionalities, including continuous monitoring of brain activity in real time, are integrated and combined in the human-computer interface, appear feasible. As a result, there is a heightened susceptibility to strong manipulation or influence over (environmentally relevant) human behaviour.

Digital everyday environments under the magnifying glass for environmental research

Digital assistants and companions gather information about us, our living environment, and themselves. In doing so, they penetrate the daily lives of individuals to a degree that reveals insights into environmentally relevant micropractices. This enables the collection of a new calibre of data that can be digitally processed and coded so it can be made available to behavioural, cognitive, consumer, and environmental research.

Furthermore, the digital living environments themselves are known to be resource-intensive, and it is



essential to consider indirect and systemic effects in a holistic environmental assessment. Although a holistic and high-quality assessment of everyday life based on digitally documented micropractices has not been fully achieved yet, it is coming as digital technology becomes increasingly integrated into our living environment.

People may now increasingly choose to digitally record their daily activities (at home, in the office, when consuming food and water, etc.) out of personal interest. They can experiment with this data playfully, reflect on their behaviour and its environmental impact, or even make their data available to scientific research (Interview 3). If the environmental protection usability of data obtained from digital assistants and digital companions improves, new environmental scoring and nudging opportunities will emerge for environmental research and administration.

Influencing behaviour in areas of conflict between competing interests

Digital environments, digital assistants, and digital companions have so far been primarily oriented towards user interests and the commercial goals of service providers. In addition to deterministic systems configurable by providers or consumers, the incorporation of AI technologies is gaining popularity. AI can be designed to assist human decision-making, but it also has the potential to act autonomously. Finding the right balance between freedom and authoritarianism is crucial in these contexts. The situation in close-range proximity human-computer relationships can be even more complex and nuanced. Brain-machine interfaces enable the observation and manipulation of typically human cognitive and affective abilities from an external perspective.

In reality, human behaviour in daily life is often not entirely rational, and individuals' genuine environmental motivations do not always translate into environmentally responsible behaviour. Artificial intelligence can be used to detect and replicate these human behaviour patterns, including their environmental impact. Scoring and nudging in the digital living environment pose a threat to and can potentially erode people's autonomy over their day-to-day decision-making. This, in turn, could impact people's sense of responsibility for their actions. On the other hand, it can be argued that nudging in digital environments or with digital assistants and companions is an ongoing occurrence and raises questions about whether the provider or the user should have control over these interventions in the public interest. Additionally, artificial intelligence can draw false conclusions from the data it is trained on, which can be revealed by human judgement. As a result, the combined use of human and artificial intelligence has the potential to mitigate their respective vulnerabilities.

The acceptance of scoring and nudging is likely to be determined by factors such as data and decision-making sovereignty, transparency of data and algorithms, and the reliability of the processes involved. Transparency regarding one's own consumption habits can evoke discomfort. In the context of a scoring system, individuals may be hesitant to acknowledge or disclose their own carbon footprint. Invoking public interest may be viewed as an attempt to exploit the concept of solidarity to compel citizens to conform to a nudging system. Reducing day-to-day decisions through state intervention would probably be met with low acceptance and legal hurdles. The extent of state action appears to be limited to decision-making support here. Power of definition is achieved by providing data and empowering individuals to determine its significance. If the state identifies the need for interventions in the context of environmental protection, it must clarify who precisely determines what, and this must be clearly and comprehensibly communicated within a trusting relationship between citizens and the state.

Data protection poses a significant obstacle to implementing scoring and nudging systems (including public-interest-oriented systems) due to the intrusion into the private living environment. A review of the use of such everyday data for scoring and nudging systems may trigger a debate on corporate invasions of privacy and their limitations. The government may be able to rely on willingness (in the form of data donations) for environmental protection on data protection-compliant systems for self-scoring or self-nudging. However, in this scenario, it would be reliant on collaborations with technology corporations.

Ability to perform digital tasks in everyday life

Any delegation of activities from humans to technological systems involves both the acquisition and loss of specific competencies and skills. For instance, the widespread use of navigation devices has reduced our ability to read maps and navigate without assistance. However, it has also allowed us to develop skills in using these devices effectively. This section aims to identify the requirements for competence development in the various ways people interact with computers as an integrated part of their living environment.

As the digitalisation of our living environment progresses, it also changes our expectations of state action, individual responsibility, and solidarity. The lack of reflection in our daily behaviour does not mean it is immune to reflection and modification at certain points. Developing digital competence also involves intentionally building relationships with the digital living environments.

Purposeful, parasocial, and close-range proximity relationships with computers and their impact on social relationships and our connection to the environment warrant deeper reflection. It is crucial to conduct research and determine the conditions for successful relationships, and the relevant relationship competencies and skills should be established and nurtured among the general population through awareness-raising and education. This requires the creation of suitable campaigns and forms of education.

Alongside STEM education[18], AI tools could employ hybrid systems of self-regulated, inquiry-based learning for human self-activation, creativity, critical thinking, and the promotion of human relationships. These action competencies are fundamental to socio-ecological transition processes.

Scope and limits of living environment digitalisation

Even in a highly digitalised everyday existence, analogue elements will persist. These non-digital aspects of life may gain increased qualitative significance as their scope diminishes. The weighing and balancing of analogue and digitally permeated living environments also requires a holistic assessment that includes environmental effects.

Ethical discussions on topics such as the Internet of Things, affective computing, and digital enhancement are already taking place in the appropriate forums. However, it is currently not possible to fully explore the social, ethical, and legal benefits and risks associated with these three modalities of human interaction with digital technology. In strategic positioning on the digitalisation of the living environment from an environmental perspective, however, social, ethical, and legal considerations must be taken into account so that the realisation of transitional potential is not compromised by short-sighted views when developing action strategies for environmental protection.

Possible environmental research and governance tasks

Digital technology's penetration into the living environment requires environmental research and governance to acknowledge and address the changing approaches to knowledge and action. Under the prevailing digitalisation paradigm, there is a risk that other, potentially more effective environmental protection measures may be given lower priority

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(cf. Section 2.1). Given that, by definition, everyday life encompasses all significant aspects of life, it is crucial to avoid isolated research and environmental policies that solely focus on individual sub-areas of everyday life.

- Before examining the environmental implications, a praxeological and ethnographic investigation must be conducted on digital technology's penetration of the entire living environment and its associated everyday behaviour. This research must explore aspects such as places of residence, duration of stay, micro-activities, social and digital interactions, and the specific role of digital technology within these contexts. This enables digitally permeated everyday behaviour to be captured and made available for environmental research and governance.

- The environment department should investigate and clarify whether and, if so, through which interfaces the possibilities of recording behaviour with its environmental impacts (data collection and input into information aggregating systems) and influencing behaviour in an environmentally responsible manner should be used. Partnerships that have not yet been explored, such as with refrigerator manufacturers, could also be considered. They could provide environmentally relevant information, regarding the expiry date of food or the increase in electricity consumption when a hot pan is placed inside the refrigerator, for example. This ecofeedback directly raises individuals' awareness of the environmental consequences of their actions. From footprinting and benchmarking to social scoring and negative or positive social credit incentives (e.g. digital awards with non-fungible tokens (NFTs), cf. Section 2.8), there is a wide range of possible interventions with varying degrees of influence on everyday behaviour. It is also possible to consider forms of nudging that go beyond aspects such as technical presets and take emotional factors into greater account. Important distinctions must be made between what is possible, what is preferable and what is permissible in terms of environmental impact.

- Given the stubborn refusal of large segments of the population to sacrifice their freedom, values and way of life (Blühdorn et al. 2020), the widespread acceptance of digital technologies, and the urgency of global environmental problems, the technological option for environmental governance can be an effective and feasible lever for relatively rapid and drastic reductions in resource consumption in everyday behaviour. In addition to influencing environmentally relevant behaviour through nudging, the targeted penetration of the living environment with digital technology enables additional forms of environmental governance, such as the levying of micro-taxes on forest entry. In this regard, the digitalisation of the living environment must be subjected to a comprehensive and holistic examination and evaluation, despite any reservations regarding data protection and the influencing of individuals.

2.4 The next-generation internet – "Metaverse", "Web 3.0", or "Splinternet"?

Trend: Creating the next-generation internet, including a seamless virtual space that incorporates the convergence of physical and digital reality.

Emerging issues:

- The metaverse as a new realm of opportunities and risks for users
- Changing human-technology-environment relationships
- Research in and for the metaverse
- Internet governance for the next generation

In brief:

- A number of factors are shaping the next-generation internet. Large digital platform companies are investing heavily in the development of the metaverse, which consists of immersive digitally augmented worlds (augmented reality) and virtual worlds (virtual reality). The Meta Platforms Metaverse refers to the commercial exploitation of all the digital platforms the group operates, where people from all over the world communicate, play, learn, create, work, consume and travel. In short, live.
- Immersive internet worlds such as the metaverse have the potential to change environmental research (e.g. the collection of data on environmentally relevant behaviour through augmented reality) and environmental governance (e.g. the active presence of environmental authorities in the metaverse). There is a need to identify the net effects of "migration" to immersive worlds, including its impact on the analogue world and the resulting changes in the scope for environmental protection.
- In the metaverse, it is expected that people will spend a significant part of their lives under the control of the platform companies. The governance of the metaverse must be supplemented with an environmental component, and environment departments must consider the extent to which they incorporate their governance into the metaverse and shape it through media.

Background: what it's all about

The general evolution of the internet ecosystem is also a crucial framework condition for environmental research and governance that needs to be considered for virtually everything (Renda 2020). Web 3.0, various heavily politically motivated alternative regulatory concepts and the so-called metaverse are among the development directions currently under discussion worldwide.

- The Web 3.0 vision places data ownership and control in users' hands (rather than digital platform companies).[19]
- The European Commission's Next Generation Internet initiative defines the future internet as an interoperable platform ecosystem based on the principles of openness (open source), inclusivity, transparency, privacy, cooperation and protection of data.[20]
- The so-called metaverse refers to heterogeneous visions in which the internet becomes an immersive, cyber-physical world that complements the real world (Peters 2023). Currently, the company Apple talks about spatial computing in this context.

Countries vary in their approaches to internet sovereignty (including sovereign access control and content regulation), global internet regulation, or unregulated internet development. In addition, privately created "walled gardens" for specific purposes and algorithmically induced "information bubbles" are on the rise. It is possible that, in the not-too-distant future, several competing notions of the internet will coexist, leading to a "splinternet" or the fragmentation of the protocols and specifications that currently make up the global nature of the internet ("World Wide Web"). The result would be fewer interconnected subsections of the internet with different governance approaches and cultures.

Current research suggests the emergence of a metaverse, although it is still unclear how the future internet will be regulated and whether it will still be a World Wide Web or a splinternet. This future topic profile focuses on the metaverse because this vision may raise new issues for environmental research and governance. The metaverse is technically defined as a virtual augmented digital space. Augmented reality (AR) is created through interfaces between physical and digital life (visual, haptic, acoustic, etc.). AR is thus also a component of the digital penetration of the living environment (cf. Section 2.3). In this section, however, it is discussed as a critical component of the metaverse, allowing, for example, the display of digital information about buildings by viewing the physical buildings through cyber glasses during a city tour. In the metaverse, virtual spaces (virtual reality, VR) will be linked as seamlessly as possible, allowing users to move intuitively between different environments and activities, just as they would in real life. When referring to immersion in the metaverse, people often talk about immersion to the point of presence, where the virtual environment is perceived as real, and the physical environment is no longer perceived.

In 2020, the Meta Platforms group adopted the term "metaverse" as part of its restructuring. Since then, Meta Platforms has been a major influence on the concept of the metaverse. At the same time, competing platform companies such as Amazon, Microsoft and Google have developed their own activities for a metaverse that spans multiple virtual spaces. Other companies, such as Samsung, Nike and Walmart, have created limited digital experiences in response (Best 2021). In addition, developing open metaverse platforms based on the principles of decentralisation and open source is attracting increasing investment.[21] Uncertainty remains about whether the metaverse will be a closed or open platform with access for other commercial providers (Amazon, Google, Microsoft, etc.) or non-commercial providers (such as government, civil society organisations and research).

In the metaverse, behaviour that is currently taken for granted is stimulated in a new way on the internet. The Meta Platforms Metaverse refers to the commercial exploitation of all the private and public digital platforms that the group operates through its platforms, where people from all over the world communicate, play, learn, create, work, consume and travel. In short, live. The metaverse should be attractive because of the new experiences and economic opportunities it offers. For example, shopping will

19 Web 3.0 — The Next Generation of the Internet (nisum.com)
20 Next Generation Internet initiative | Shaping Europe's digital future (europa.eu)
21 The metaverse has not arrived yet! (cryptonews.net)

become an activity that allows simulated haptic contact with the products through AR and provides a personalised experience through gamification, in other words, playful elements that cannot be experienced in this way on the internet today. Individuals can be represented by avatars (VR) with algorithms to perform desired tasks, such as initiating business relationships.

The concrete realisation of all the different virtual and augmented worlds (extended reality), their linking and overlapping to form an overarching metaworld, and the future power and ownership relationships within it, will shape people's way of life, their options for action and decision-making, their access to knowledge, and their long-term values and beliefs. The chosen focus on the metaverse here addresses a currently relevant development of the next-generation internet without excluding other developments that may be preferable from a public-interest perspective.

Drivers and trends

The building blocks of the metaverse consist of six layers with their respective technical drivers: infrastructure (microchips and processors, cloud computing infrastructure, etc.), access/interfaces (headsets, augmented reality/virtual reality glasses, haptic suits, natural language processing, etc.), virtualisation tools (3D design tools, avatar development, etc.), centralised and decentralised virtual worlds, economic infrastructure (digital payment systems, NFT marketplaces, etc.), and experience worlds (games, virtual property/real estate, crypto wallets for storing digital assets, etc.).[22] Basic technologies such as artificial intelligence and blockchain are the main technical drivers for the development of metaverse applications. Monitoring user behaviour and ensuring cybersecurity are critical supporting services for the operation of the metaverse.[23]

With non-fungible tokens (NFTs), also referred to as non-exchangeable digital objects and assets (see also Future Topic 2.8. Digital Money), unique real-world objects are digitalised and sold, or unique digital objects are created and registered using blockchain technology (Best 2021). At the moment, NFTs are mainly used for collectables, art and games but are also used in virtual experiences and retail spaces (e.g. exclusive brand offers from Prada, McDonald's and Adidas). NFT applications for virtual real estate trading already exist in the metaverse (Decentraland, The Sandbox). NFTs have given rise to new business models for the metaverse that market authentic uniqueness or create commercially exploitable incentives in gaming (Decker 2022). However, the promise of an enhanced virtual experience and added value has so far only been partially realised. Instead, everyday life and its quality are often perceived as being monetised. The dynamics of games, for example, are designed to encourage spending ("pay to win").

So far, privately operated social media platforms have driven this socio-economic development. They serve as a mass medium for public and private information and communication and perform functions such as setting the agenda on current major issues, reaching large segments of the population, exchanging knowledge and products, maintaining social relationships and developing social norms. The business models of the few major platform companies are based on data about user behaviour, which they combine with other data and analyse using machine learning to generate, for example, personalised content,

22 The metaverse could be tech's next trillion-dollar opportunity: These are the companies making it a reality – CB Insights Research.
23 The metaverse – more than simply Second Life 2.0? | Bitkom Akademie (bitkom-akademie.de)

pricing models and advertising. In a recent survey, 10% of respondents in Germany said they could imagine moving their entire lives into the metaverse, 64% could imagine doing so at least partially, and 27% would not accept moving even parts of their lives into the metaverse (Duwe et al. 2022).

Meta Platforms has implemented several pilots that suggest an exploratory and reflexive metaverse construction. In "Horizon Worlds", which opened in late 2021, adults can conduct free research together and create their own meta-world using the most advanced development tools. Horizon Workrooms have created a virtual working environment where users can, for example, join a meeting using their avatar. It remains to be seen whether people will find the anticipated activities in the metaverse beneficial and relevant and whether they will be able to manage their lives in the metaverse easily. The metaverse will need to demonstrate a clear added value over other online platforms such as Microsoft Teams and analogue formats such as face-to-face meetings to succeed.

In August 2022, the Hype Cycle model developed by research company Gartner depicted the expectations for the metaverse as experiencing a rapid ascent. However, the plateau of productive use is not expected to be reached for more than ten years.[24] Meta's share price has recently plummeted,[25] but this does not preclude the metaverse from gaining momentum again in the future.

The metaverse is expected to perpetuate the familiar distribution of power on the internet and even intensify it, with fewer and more powerful commercial players: "The most successful company will have the unique opportunity to simultaneously become the Apple, Facebook and Amazon of the future." (Duwe et al. 2022). Before a single winner emerges, there is likely to be a conflict over whether the metaverse will be a closed or open platform, allowing access to other commercial or non-commercial stakeholders. The companies that make up the metaverse take on a quasi-infrastructure role for users, facilitating contact, inspiring, helping with daily life and providing experiences.

Emerging issues

As powerful internet platform operators, few global and competing corporations have a vested interest in promoting the interweaving and overlapping of different virtual spaces. Users are assured that they will be able to move freely in the metaverse, i.e. across seamlessly connected virtual spaces, using a single user profile. The dominating internet platform operators have a strong interest in linking and commercially exploiting the vast amounts of data generated by different applications and functions.

Through the evolution of digital tools and platform convergence, the metaverse is bringing individuals, businesses and governments closer together as it evolves. By moving more and more private and public, economic and governmental activities onto internet platforms, the metaverse also represents the next stage of digital society, including new ways of understanding place and time, opinion formation, decision-making and social behaviour.

The continued development of the internet under the direction of a powerful technology corporation will lead to the escalation of some known emerging issues. Governments, industry and society are already debating regulation, privacy and vulnerability to cyber-attacks, but the metaverse may emerge before all the risks have been adequately addressed.[26]

What changes in society will accompany the transition from everyday life to the metaverse? How will this affect the relationship between individuals and their real-world environment? What opportunities does the metaverse present for environmental research and governance? What risks must the environment department anticipate?

Several overarching emerging issues arise:

The metaverse as a realm of opportunities and risks for users

Users' awareness of and reflection on the transition between activities, such as between creative leisure and commercial activities, is reduced by the seamless transition between virtual spaces. Rationality requires time, which is particularly important for commercial

24 Gartner's latest hype cycle rates metaverse as 10 year+ journey – Ledger Insights – blockchain for enterprise
25 Meta Stock Crash Steepens As Facebook Parent Grapples With Recession Fears (forbes.com)
26 3 global risk areas that demand cosmic action in 2022: Space, the metaverse and Planet Earth | World Economic Forum (weforum.org)

activities. Beyond-the-moment rational reflection is no longer possible under conditions of digital influence below the consciousness threshold (Han 2021). Users will ostensibly experience a sense of autonomy but, in reality, will be subject to an economically motivated, fluid control of their attention by a monopoly of profit-driven corporations. The physical world will then be perceived and altered primarily by digital means. Users will be highly susceptible to cognitive manipulation through immersion in the digital augmented physical and virtual realities.

Technical advances in virtual and augmented reality and the lack of socio-political regulation at the international level will encourage digitally competent users to generate income across borders in the metaverse. To do this, they will use avatars to represent themselves as facilitators, intermediaries or contracting partners. This form of professional independence will create winners and losers among metaverse users during a less-regulated pioneering period, highlighting the need for regulation. Users may interact with avatars as if they are people (anthropomorphisation) (Erdmann und Röß 2020).

Metaverse operators are highly likely to be among the winners, although users may be unaware of this due to the seamless transition between their activities. In the metaverse, data can be analysed in real time and used for interventions in the metaverse – again in real time. This opens up huge potential applications and growth opportunities for artificial intelligence (AI) in business analytics. It must be clarified which stakeholders should have access to which data and for what purposes, who makes that decision and who monitors compliance.[27]

The metaverse will rely heavily on machine learning. Humans perceive the world in a biased way, and biases are also written into algorithms. Machine learning algorithms can help debias human behaviour, but they also carry their own discriminatory biases. With the mass shift of activities to the metaverse, actions will also be delegated to algorithms, so algorithmic bias in the metaverse will be a key challenge.

In the metaverse, people and avatars can move seamlessly between different virtual spaces, enabling data connections between previously separate physical and virtual spaces that go far beyond today's quantitative and qualitative big data combinations. The challenges of human control and management of processes, i.e. autonomy, need considering in terms of information, privacy, freedom of expression and decision-making. As the construction of the metaverse progresses, the convergence of human and artificial intelligence and the technological enhancement of humans will become even more significant. Humans' cognitive and affective capabilities will become even more vulnerable to external observation and manipulation. The ethical and legal risks must be discussed to understand and regulate the consequences and desirability of access to personal data and information about individual opinions and decisions.

Everyone must have access to the metaverse. The ability to navigate and benefit from the metaverse will vary greatly. Users can get their "fingers burned" during their self-expression within the metaverse, which is why specific metaverse literacy will become more important than general media literacy.

At the same time, the desired transfer of an increasing number of activities into the metaverse and navigation under a single integrated user profile will require exceptionally high levels of cybersecurity, protection of user data and protection against manipulation. In general, a map is needed to show whether there are qualitatively new risks and dangers in the metaverse compared to the internet, big data and AI that need addressing in the public interest. Misinformation about climate and environmental issues and group-specific environmental communication are well-known difficulties on the internet.

Users floating in the metaverse do not know how many and which virtual worlds are connected via the cloud and which are excluded. Even the cloud itself does not reflect this inclusion/exclusion boundary. Only the commercial interests of the metaverse operators seem to be instrumental in this respect (Interview 1).

27 The metaverse – more than simply Second Life 2.0? | Bitkom Akademie (bitkom-akademie.de)

Human-technology-environment relationships within the metaverse

A technologically generated and mediated world/environment in the metaverse modifies people's relationship with nature, consumption and environmental behaviour and thus has multi-layered relevance to sustainable development. Four areas stand out: education and research, (private) life, work and business and opinion formation:

In the field of "education and research", for example, the metaverse could create new opportunities by linking individual virtual applications, improving access to environmental data, information on the human-environment relationship, and measuring the environmental impact of human actions. An increasing number of digital interfaces in and with the environment are emerging and becoming interconnected. These can be used to gain knowledge about the environment and create entry points for misuse. This raises the question of the extent to which humans' anthropogenic and natural environment should be incorporated into the metaverse via AR. For example, animals could be connected to the metaverse and engage in digitally assisted communication with humans. People in the metaverse perceive their physical and digital environment differently than in the analogue world. This creates new opportunities and risks for (environmental) education. The long-term integration of formerly separate data spaces creates opportunities to combine anonymised data from widely different scientific disciplines, standardise it, and make it analysable for various services.

The current commercial direction of the metaverse shows little public-interest-oriented emphasis on promoting education and research for sustainability.
In the future, the metaverse is expected to be a key source of data for commercial stakeholders and a critical arena for influencing behaviour in accordance with their commercial interests. How can adequate access to the metaverse also be enabled for public-interest-oriented, basic, and sustainability research?

How will public-interest research processes be initiated, organised, conducted and evaluated in the metaverse? Are independent research infrastructures needed for this, and what might they look like?

As a consequence of the metaverse, significant changes are expected in the (private) life field of action, particularly the further migration of physical activities into the virtual space (e.g. work, shopping and entertainment). At the same time, augmented reality and its interfaces will superimpose new digital layers of meaning on the analogue world.[28] Therefore, the aim is not only to compare physical and virtual equivalents from an environmental point of view but also to document qualitative changes and innovations in everyday life and lifestyles (including living, consumption patterns and sleep) in their entirety.

This also involves fundamental shifts in the perception of the environment in terms of place and time. As evidenced by the repurposing of spaces in the aftermath of the COVID-19 pandemic (the kitchen as an environment for virtual learning, the bedroom for virtual work, etc.), digitalisation is changing people's sense of space and their attachment to places. Repurposed for new activities, places become transit spaces, i.e. places to which a new type of attachment is formed (the office as a meeting and creative space) or sometimes no attachment at all (flexible office workspaces). The migration of different activities into virtual spaces makes them all accessible at the same time through a single digital access point, making time allocation to particular activities extremely challenging. People's perception of time and, consequently, their relationship to their (circadian) biorhythms change in the metaverse. In the metaverse, the functional redefinition of places and the fragmentation of time could reach extremes.

The work and business field of action raises the question of specific changes brought about by the metaverse, especially in light of the extensive migration of activities to the internet during the COVID-19 pandemic. This is a difficult question to answer at this stage of the metaverse development. Depending on its design as a Meta Platforms domain, the regulation of access by other technology groups, the openness to business models and the virtual spaces created from the ground up, the future world of work and business in the metaverse will take different forms. So, to some extent, will the environmental impacts of these activities.

What additional work and economic activities will the metaverse move into the virtual realm? Which will be newly created, and where, and which will continue to be physically implemented, such as in the craft or construction industries? How do informational, financial and physical transactions take place in the metaverse? What are the organisational structures of companies and markets in the metaverse?

In the opinion forming field of action, the question arises as to how linking previously separate data platforms through the metaverse affects the forming of opinions. Various models are conceivable, ranging from targeted manipulation of opinion formation throughout the metaverse to fragmented islands of opinion formation that could establish fundamental opinion relativism. Information about attitudes and behaviour could be evaluated anonymously, and feedback could be provided on both the individual and collective effects of behaviour. In terms of opinion formation, algorithms have an ambivalent potential, depending on whether they support the biasing or debiasing of individuals during information searching, navigation, reasoning and opinion formation.

Since empathy is necessary for generating public awareness and mobilising resources (such as donations for environmental protection and petition signatures), environmental communication in the metaverse is also a crucial aspect for the environment department. Imparting non-verbal communication elements is one of the difficulties of communication. Combining virtual reality (VR) technology with affective computing could enhance immersion by recognising gestures, eye movements and facial expressions, thereby reducing previous communication problems.

28 Section 2.4 deals with the digitalisation of everyday objects and environments.

Research in and for the metaverse
In France, Meta Platforms is setting up the Metaverse Academy. The aim is to teach students how the metaverse works and can be expanded while recognising that few of the jobs of the future have yet been invented.[29] Meta Platforms has announced that it will fund independent research into the opportunities and risks of the metaverse with 2.5 million[30] euro and establish a metaverse research centre in Europe. Stakeholders involved in the governance of research in Europe should take a stance on this and work to shape the public-interest research agenda. The EU Open Science Cloud (EOSC) and German National Research Data Infrastructure (NFDI) are taking a clear stance in relation to metaverse research. Harvesting data from all private and public stakeholders in research and development requires the interoperability of processing systems and interfaces.

The metaverse's direct energy and resource consumption will be an important area of study. A massive development of the digital infrastructure will accompany the expansion of the metaverse to manage the vast amounts of data it generates. Meta Platforms, formerly known as Facebook, is a global leader in digital terrestrial and submarine infrastructure investment.[31] The construction, operation and future management of the metaverse, with its data centres, transmission stations, end devices and peripheral components, requires the estimation and minimisation of energy and resource requirements.

Due to the lack of clarity about the shift of activities to the metaverse and the uncertain impact on the analogue world, it is currently impossible to make meaningful general statements about the indirect and systemic environmental effects. It is essential to consider the unique characteristics of the metaverse, namely the seamless integration of augmented and virtual reality and navigation with an integrated user profile, and to clearly distinguish the metaverse from today's internet with its known issues, such as changing mobility and consumption patterns due to online retail. Significant potential for change exists, for example, in shifting activities and their respective ecological footprints, reducing transaction costs in the search for environmental information, and establishing sustainable or non-sustainable application areas, such as purchasing (3D-printed) spare parts.

Governance of the metaverse
The future of metaverse governance is highly uncertain. Powerful digital platform operators strive to shape and govern them in their own interests. Although Meta Platforms is currently the driving force, in the medium term, other stakeholders in other functionally similar metaverses may gain greater economic power than Meta Platforms, allowing them to govern how interests are implemented and negotiated in novel ways. It is also necessary to consider the role of state governance in the emergence of the metaverse economy.

If the metaverse turns out to be primarily an enabling platform, then newly configured social subsystems (such as digital assets or research and development) that follow their own logic co-determined by Meta Platforms could emerge there in the medium term. A mosaic of different proprietary logics and governance styles could emerge in the metaverse, each with its own regulatory requirements.

From an overarching perspective, the question arises as to what extent the metaverse arising from commercial interests, with its enabling nature for subsystem governance, will be receptive to democratic metagovernance. Depending on the location of the dominant institution, the availability of starting points for democratic governance may vary in Germany and the EU. This requires an early, e.g. at the European level, initiation and pursuit of the development of international governance structures and processes for a sustainable metaverse. In this respect, there will be a struggle surrounding the metaverse as a private or public domain (cf. Section 2.9).

Possible environmental research and governance tasks
Beyond the isolated analysis of individual developments at different internet levels (increasing computing and transmission power, the Internet of Things, distributed computing, the spread of artificial intelligence, blockchain, etc.), it will be necessary in the

29 Meta launches the Metaverse Academy in France (contentmanager.de)
30 Supporting Independent Metaverse Research Across Europe | Meta (fb.com)
31 (21) Environmental Manager | Meta | LinkedIn

future to keep an eye on all areas of the internet ecosystem (the current generation internet with its open and closed sub-areas, the darknet, the metaverse, etc.) to realise the full potential of this new world – including for environmental research and governance.

Due to the connection of the physical world with the virtual world (AR) and the shifting of essential components of all areas of life into a single, constantly evolving virtual world (VR), the environment department must examine the possible effects of the metaverse on environmental research and governance in all fields of action.

- On the one hand, the question for the environment department is whether the known internet challenges (e.g. concentration of power in the hands of a few platform companies and cybersecurity) will change as a result of the metaverse and whether new challenges will arise as a result of the connection of the physical world with the virtual world, the connection of virtual spaces, stakeholder groups and user agency in the metaverse. On the other, the metaverse has the potential to change environmental research (e.g. the collection of data on environmentally relevant behaviour through augmented reality) and environmental governance (e.g. the active presence of environmental authorities in the metaverse).
- For environment departments in Germany and the EU, formulating requirements and possible forms of governance and regulation in the metaverse is of particular concern, especially from an environmental perspective. In this context, it is necessary to reevaluate the potential and scope of a partnership between the environment department and the platform companies to achieve environmental policy goals. How citizens could participate and collaborate in environmental governance through the metaverse needs to be explored. In the future, the metaverse must also be understood as a research entry point and subject.

- From an environmental perspective, there is a need to identify the net effects of “migration” to the metaverse, including its impact on the analogue world and the resulting changes in the scope for environmental protection. The environmental effects of the metaverse can be categorised into direct, indirect, and systemic effects:

  - It is expected that the construction and operation of the technology for the metaverse, and the exploding data streams resulting from the expansion of the moving images, will have a significant direct impact on resource consumption and the environment (including the energy consumption of data centres, the demand for environmentally relevant raw materials, and the dissipative use of strategic raw materials). Direct environmental impacts are, by nature, negative.

  - The first step in determining the indirect effects of the metaverse on resource consumption and the environment is to determine the nature and extent of the migration of areas of life to the metaverse, and the second step is to determine the changed patterns of activity and their effects on resource consumption and the environment. The indirect environmental effects may be positive (e.g. less resource-intensive leisure activities in the metaverse compared to travelling to leisure activities) or negative (e.g. blockchain-based digital currency transactions as opposed to traditional online banking). In addition to being sent to engage in commercial activities in the metaverse, avatars can also be given a sustainability agenda.

  - The systemic effects of individual activities in the metaverse include monetary and time rebound effects, in other words, “saved” money or time spent being reallocated to other activities. The systemic repercussions of linking areas of life from the physical world to the virtual world and linking virtual spaces to the corresponding areas of life within the traditional internet, in alternative future structures, and in the physical world must be evaluated.

- In terms of environmental governance, the focus is on promoting sustainable behaviour in the metaverse. The potential of social media in the metaverse for providing and using scientific data from environmental research and promoting sustainable behaviour needs to be recognised and used effectively. As the digitalisation of society continues into the metaverse, new narratives for sustainability and human-technology-environment relationships will be needed, as will new VR and AR-ready formats of multimedia storytelling for targeted communication within the metaverse, tailored to specific audiences.

2.5 Digital Statecraft – revitalising democracy and catalysing a socio-ecological transition?

Trend: The growing need for "statecraft" coincides with expanding digital and digitally supported capabilities

Emerging issues:
- Opinion and will formation, participation, and involvement in the digital public sphere
- CrowdLaw
- The digital state as a new technological regime

In brief:

- With the rise of social media and the changes in traditional media brought about by digitalisation, a new form of public sphere is emerging in which the logics of the digital attention economy have a significant impact on opinion and will formation. The formation of opinion and will is accelerated by pre-reflexive communication and can be manipulated. At the same time, however, the threshold for participation and representation is lowered.

- For the state, the transformation of the public sphere through digitalisation may mean systematically and dynamically involving citizens in public (state) affairs (cybernetic citizenship). Digital tools enable citizens to participate more frequently, widely and effectively in processes ranging from identifying needs to legislative procedures (CrowdLaw). This could contribute to revitalising democracy, which would also result in improved socio-ecological transition processes.

- Training in digital statecraft would create a new technological regime to support strategic and operational state action in uncertain conditions. The primary goal is to identify and implement the technical solutions and regulations for State 4.0 that enable personalised citizen services, automated control processes and participatory engagement formats while at the same time being integrated into higher-level (possibly global) governance structures.

Background: what it's all about

Digitalisation is changing the scope and limits of state action by expanding and qualitatively modifying the possibilities for both the state and citizens. "Democracy in the Democratic Constellation" (Thiel 2020) encompasses three central areas: the transformation of the public sphere, the transformation of representative democracy associated with digitalisation, and the transformation of democratic rule. Digitalisation, therefore, challenges political science and political theory to rethink the public sphere, participation and representation, and the state's ability to act in uncertain conditions (statecraft).

Under the category of structural changes in the **public sphere**, the effects of digitalisation on communication, the media landscape and social cohesion have been discussed in various ways recently (Habermas 2022). As a result, communication increasingly occurs in disrupted public spheres, subject to hidden commercial interests, characterised by deception and manipulation, and leading to echo chamber effects. Although a still diffuse form of digital citizenship is emerging that includes opinion and will formation and political campaigning in social media, such a digital public sphere undermines deliberative politics. (Habermas 2022).

At the same time, opportunities for **participation** in political processes are diversifying and expanding within the digital society. Concepts such as digital democracy advocate enabling participation in constructive public debates in cyberspace and activating and involving people in political processes to promote a vibrant and participatory democracy (**representation**) (Indset 2021). This citizen-centred view complements the state-centred view of digital statecraft.

Digital statecraft is the strategic and operational action of an active and capable state that organises collective action to channel the transformative power of digitalisation towards socio-ecological transition (Ramesohl und Losse-Müller 2021). The increase in the complexity of state action is a significant factor in the growing need for statecraft, as government decisions are increasingly made in uncertainty and, therefore, bounded rationality (Korte et al. 2022b). The channelling of the transformative power of digitalisation towards socio-ecological transition is not inherent to process-oriented digital statecraft, but it is possible in terms of content.

Digitalisation is fundamentally changing the relationship between citizens and the state. This section explores the concepts of digital statecraft and digital citizenship and how they are interconnected. The focus is on participation in decision-making and political processes and the state's digital responsiveness to its citizens' needs (provision of public services in areas such as health and safety, participation, sustainability transition, etc.). The following sub-sections will cover automated government administration (executive), including digital public services and legal tech (judiciary). "Data-intensive processes in research and policy" addresses data-centred issues.

Drivers and trends

Examples of current trends include an increase in digital literacy and devices in the state and the population, the growing role of digital technologies in communication, opinion formation and social relationships, and the information and experience platforms provided by the state[32].

The crisis of democracy is almost as old as democracy itself. In the face of disillusionment with politics, declining membership of political parties, declining long-term[33] trust in state institutions, and the simultaneous shift of life into digital realms, the post-democracy era is being declared, and there are calls for a revival of democracy.

The megatrend of digitalisation does not stop at the state and its institutions. Concepts such as State 4.0 (personalised, automated and participatory) are deliberately put on a par with Industry 4.0, where each stage in the development of industry equated to a revolution. From a sobering perspective, the state is a late adopter of many digital technologies compared to industry ("fax machines in health departments") but often a pioneer in sovereign tasks, such as monitoring territorial integrity and authenticating people.

In the context of smart cities, where Germany is also considered to be a latecomer internationally, beyond the digital networking of public service systems (transport infrastructure and logistics, energy and water supply, building and housing management, waste water and waste disposal, health, etc.),

32 cf., e.g. UNEP Environmental Situation Room: Main page | WESR (unep.org)
33 Strictly speaking, it is necessary to make social distinctions and to differentiate between the period before and after the COVID-19 pandemic and the Ukraine conflict. It is currently impossible to predict whether the current crisis mode with a strong state will continue or whether there will be a return to the previous mode of questioning state institutions.

concepts for the digital integration of citizens in public decision-making and planning processes are being pursued.

Emerging issues

In Germany, some emerging issues such as cybernetic citizenship – that is, citizens who are systematically and dynamically involved in public (state) affairs, CrowdLaw, or live platforms for participation and networking between the state and its citizens – are still in their infancy. Despite the generally positive connotations of citizen participation, the fact that governments and individual agencies are also using digital technologies in ways that pose a threat to digital citizenship, such as the use of the Pegasus software to spy on journalists, thereby undermining fundamental press freedom rights such as whistle-blower protection, should not be a secret (Streck 2021).

Digital citizenship – opinion and will formation, participation and involvement

Information in the digital space can be neutral, distorted or manipulative, correct or incorrect, and is often not recognisable as such. Citizens' reactions to this information can shape their opinions and will. Social media accelerates **opinion and will formation**, creating a tendency towards mainstream narratives that community members must adhere to (Interview 1).

In digital systems and social media, there is a high risk of perpetuating or reinforcing inequality and discriminatory opinions due to biases. Issues such as nudging, echo chambers, manipulation by social bots and deep fake are currently raising public concern. Opaque, inaccurate or even manipulated algorithms or disinformation are often behind this. The deliberate manipulation of opinion and will formation can now occur on such a large scale that democratic systems and states can be destabilised. So far, there has been little use of algorithms to capture and analyse opinion formation for public interest purposes. Accelerated will formation may be beneficial for transitional processes.

So far, government environmental action has not been widely presented in these formats. Emerging issues include digitally disseminated environmental misinformation, digital accessibility of environmental communication target groups, and changes in social environmental norms resulting from increasing human-technology interaction. Serious gaming and multimedia storytelling are two approaches the state could use to become more active in this area.

It is unclear to what extent digital networking of citizens serves to advance private or public interests. In principle, networking, of citizens' initiatives, for example, has the potential to foster learning from

one another through sharing problems, ideas and experiences. This can strengthen the citizen-centred aspect of public space design. On the other hand, the digital realm is predominantly used for commercial and private purposes. In addition, there are multi-stakeholder arrangements in the digital realm (e.g. urban consumers can connect with rural areas in the context of solidarity farming). Despite this continuing lack of clarity, there are starting points for state action to promote digital citizenship.

The democratic **representation** of citizens in the digital realm has not yet been systematically documented and understood as a strategic task (plebiscitary/representative). Innovative citizen forums and participation and networking platforms with new digital possibilities (such as bottom-up agenda setting with smart city dashboards (Marsal-Llacuna 2020) and collaborative monitoring platforms for the climate neutrality of cities (City of Helsinki 2019)) could significantly contribute to boosting acceptance of environmental transformations. In the digital state, citizens articulate their normative requirements for the development of future digital applications.

The concept of cybernetic citizenship creates a new self-perception among citizens regarding their influence on the design of socio-technical systems and their environmental consequences. Citizens actively participate in providing data (e.g. through data donations) and using data (e.g. to make their daily actions more socially and environmentally sustainable). In the vision of a "real-time smart government", information on attitudes and behaviour is evaluated, and feedback on the individual and collective consequences of behaviour is provided in near real-time.

New digital technologies have benefits for active citizenship. Citizens become co-producers of knowledge in research and participative agenda-setting processes for environmental policy. Understanding their motivations is highly relevant for citizen science and data donation for environmental protection. However, being pragmatic about engagement, open governance, and co-production is important (Misuraca et al. 2020). There is empirical evidence of a decline in civic engagement and political participation in advanced democracies. It is unlikely that ICT-based solutions and the release of any public data will reverse this trend (Misuraca et al. 2020).

At the planning level, decisions could increasingly be supported by digital twins and simulations and made in near-real time with citizen participation. This is already happening in some municipalities, such as Tübingen (Technisches Rathaus). In addition to displaying planning documents, the existence of a digital infrastructure, including digital geodata and development data, and digitally literate government administration staff are prerequisites for this.

Cybernetic citizenship, crowdsourcing and citizen science are precursors to the activation of citizens for public-interest-oriented tasks, which, in the long term, could lead to a collaborative living lab society with strong civic participation and responsibility. In terms of digital participation and digital citizenship, digital literacy is becoming a fundamental skill for everyone. With the widening digital divide internationally, digital (literacy) inequality is an emerging issue in which the skills gap needs proactively mitigating.[34] The increase in learning in digital environments also raises the question of low-threshold digital learning opportunities to participate digitally in public opinion and will formation processes in order to reach disadvantaged groups and raise awareness of environmental issues.

CrowdLaw – The link between citizens and state policy in the legislative process

Digitalisation requires a rethinking of statehood as a collaborative process between citizens and state institutions. Bridging the gap between the state and citizens requires new institutional arrangements and discussions about constitutional implications and civil rights protection.

Concrete digital engagement mechanisms (consultation/decision-making) must be designed and established for specific objectives. For future workshops with citizens, it is conceivable that related topics could be generated from spoken or written contributions at the click of a button using natural language processing (NLP) (Interview 5), thereby facilitating a reflexive discussion of the group's findings and effective further processing. Real-time consultations on

34 refers to a societal divide in the basic skills required to use digital technologies.

environmental issues, for example, require considerable conceptual and technical effort, which must also take into account the active involvement of digital non-natives in environmental policy discussions.

CrowdLaw seeks to improve the acceptance and democratic legitimacy of legislation through participation.[35] The underlying principle is that the ability to form opinions is an important component of fair public dialogue. In a representative democracy, citizen participation is seen as a remedy for disillusionment with politics and a possible component of a more direct democracy.[36]

CrowdLaw is the legal practice of using digital technologies to access swarm intelligence for legislation through publicly accessible platforms. CrowdLaw is not about citizens drafting their own laws but about encouraging them to participate in discursive and normative debates about their daily lives within legislative processes. Sceptics argue that systematic public engagement is expensive and legally binding participation is impractical. Whether all citizens can participate fairly in such a rapid decision-making process is questionable. Unlike the hearings and consultations that have so far been governed by government rules, digitally organised lobby groups and citizens' initiatives have a greater chance of exerting undue influence. The use of CrowdLaw as a new form of lobbying influence, e.g. with a significant impact on environmental legislation, is one example given. Nevertheless, the groups mentioned above already influence the legislative process more or less transparently through high-profile campaigns and informal meetings with legislators.

It should be noted that both in Germany and at the European level, there are numerous procedures for involving citizens in legislative processes.[37] While there are already several references to CrowdLaw in other European countries in the sense of widespread digitally supported participation, we are not aware of any examples in Germany. Citizen participation in the legislative process seems to depend more on public culture, political will and the creation of specific conditions.

Without proper safeguards, CrowdLaw could become a gateway for manipulative stakeholders with hostile or anti-democratic intentions. Secure digital authentication could be a requirement for participation in CrowdLaw processes. In the context of CrowdLaw,

35 CrowdLaw Manifesto
36 The current core legislative process involves citizens through their elected representatives at all legislative levels (European, federal, state, municipal).
37 In the case of petitions, for example, there are questions regarding enforceability: who submits issues, for what reasons, and what are the obligations to respond? Petitions are also used to exert pressure on policy but without direct reference to the law.

digital participation needs to take into account digital biases and citizens' varying levels of digital literacy. Digital tools could also be used to determine the extent to which the submissions adequately represent the population, the presumed beneficiaries and those affected (who should be involved?), and the course of the opinion-forming processes (how did the collective opinions emerge?).

However, the knowledge base on digital opinion--forming processes is relatively limited, making it difficult to formulate minimum requirements or quality characteristics of digital discourses for CrowdLaw. As a result, in the near future, such large-scale consultations would have more of a supporting role in conventional legislative processes, but in the long term, with an improved knowledge base and digital tools, they could be given a more normatively binding effect.

The impact of simulations on crowds is a major area of research (Webster und Amos 2019). Therefore, the study and promotion of opinion formation in the digital world is a critical research task to identify and evaluate the various communication practices and strategies and define and build basic competencies in the involvement of citizens in legislative processes.

By involving citizens in legislative processes at an early stage, the CrowdLaw approach offers the potential to avoid and reduce disputes within transition processes. Clear, legitimate and legally binding instruments and procedures are needed.

If action is taken primarily at the federal level, CrowdLaw challenges federalism in Germany. In the long term, CrowdLaw could even potentially reshape the significance of various governance levels on a global scale by circumventing existing vertical cooperation between institutions and fostering a form of "world domestic policy".[38] Whether the introduction of CrowdLaw is beneficial for democracies may be dubious while autocratic and dictatorial forms of government exist in other countries.

The digital state as a new technological regime
With the digitalisation of the state, which is automated, personalised, open and participatory, a new self-perpetuating technological regime is emerging. While a case can be closed and an official letter filed away, the concept of State 4.0 gives rise to a new form of permanent statehood. A form of "open government" that is transparent to both politicians and citizens has advantages and disadvantages. The opportunities include legitimate, responsive and effective governance, while the risks include the potential for the state to misuse digital systems to control its citizens.[39]

Through accelerated decision-making and consultation processes (collective decisions in real time), digitalisation contributes to the politicisation of decisions. Old and new NGOs exert political pressure through digital means, and digital consultation formats become gateways for manipulative stakeholders with hostile or anti-democratic intentions, who form themselves into digital discourse and discussion forums. Under certain circumstances, post-democratic elements can be seen as an extension rather than a replacement of democratic processes. In the age of digitalisation, participation and involvement needs to be rethought.

Which technical solutions and what regulation does a State 4.0 need that enables personalised citizen services, automated control processes and participatory forms of involvement while also being integrated into global governance structures? The prerequisite for increased digital interaction between citizens and government is a consolidated IT infrastructure with clearly defined and legally protected interfaces and compatible data transfer tools, even between stakeholders that have not or only minimally cooperated in the past. Technologies such as blockchain can promote transparency and trust in digital processes.

At the global level, the question is how to establish a worldwide participatory decision support system (Interview 3). Such a platform-based system could be designed to allow individuals to follow all political developments that affect or interest them. This system would encourage citizens to participate in decision-making processes and, ostensibly, lead decision-makers to make better decisions in the best interests of citizens based on their input.

38 In times of crisis, such as the COVID-19 pandemic, institutions fractured and reorganised ad hoc to form a global multi-level government.
39 The lockdown of entire cities in China due to COVID-19 with the use of technological tools

In the long term, the question is whether new technologies such as AI, blockchain and quantum technology can successfully expand such a system to millions of people.

Implications for environmental research and governance

Digital statecraft will probably only be successful if the digital state generates public added value through digital services (cf. the Automated Government Administration Processes future topic), simultaneously considers legitimacy and trust, and takes into account user needs and the digital divide (Misuraca et al. 2020). There are a number of considerations that the environmental department could address specifically in relation to environmental research and governance:

- The impact of misinformation about climate and environmental issues on the internet (including censorship, deliberate misinformation, and even hybrid warfare) is likely to increase significantly. How can the credibility of sources be made transparent in a reliable and timely manner, and how can the involvement of citizens and other stakeholders in researching and developing solutions and policies be strengthened? The issue of algorithmic discrimination based on data or pre-existing attributional patterns in the minds of developers needs addressing. The potential for a leading market for human-centred, trustworthy and non-discriminatory AI in Europe must be analysed.

- Environmental communication must be sensitive to specific target groups (information and activation offers). The aim is to reach people who were previously difficult or impossible to reach with traditional information and communication offers, through online games, for example. Digital tools make it possible to present the complexity of the environment in a more accurate and understandable way. Digital storytelling is an underused tool for environmental communication. Digital environmental education is a relatively new topic.

- A feasibility study could explore the widespread use of digital twins and simulations for real-time decision support and decision-making in environmentally relevant projects in urban and regional development and cross-regional, national and transnational development.

- Participatory digital governance experiments are needed. Digital quasi-experiments and governance labs have the potential to explore a wide

range of state-citizen interactions. Public participation in debates and the participation of citizens and other stakeholders in the research and development of solutions and policies need strengthening.

- CrowdLaw has several potential applications in Germany, including disputes over wind turbine siting, approval procedures for environmentally relevant products or systems, the use of real estate, water reservoirs, and many more. CrowdLaw would need to include processes and tools that allow citizens to be more involved in developing solutions, making decisions and implementing solutions. How can citizens concerned about environmental issues participate in the legislative process? Can digitalisation enable widespread participation in CrowdLaw processes, and is this really necessary given the variety of consultation procedures that currently exist in Europe? The advantages and disadvantages of CrowdLaw need examining. How do people’s perceptions of environmental issues and legislation change when digital tools are introduced into the equation?

- There is a need to analyse the design freedom and possible scenarios regarding the environmental implications of digital governance from a multi-level governance (MLG) perspective, and the orientation of that governance towards the humanisation of the digital state. As a result, introducing digital tools raises questions about new institutional arrangements and guarantee structures.

2.6 Automated Government Administration Processes

Trend: The digitalisation of government administration, its internal processes and its interactions with citizens creates the conditions for the automation of government administration work.

Emerging issues:

- Service quality
- Position on social scoring and credit systems
- Reorganisation of internal government administration processes
- Changes in the relationship between citizens and government administration
- Government administration for a great transition

In brief:

- The digitalisation of the government administration (e-government), knowledge about the automation of business management processes, and the development of digital applications for government administration processes are the drivers for the automation of government administration. The new era of digital administrative governance would be data-centred and based on the changing role of digital technologies in the execution of government functions
- Automation solutions for environmental administration range from electronic records and AI-supported procurement and recruitment processes to automated query handling and response. Government administration relationships that need redesigning as part of the automation process include those with citizens, businesses and NGOs and cooperation models with platform operators for high-quality public services.
- At present, (partially) automated government administration processes have the greatest potential to increase the efficiency and performance of government administration. The (partial) automation of government administration will also restructure the interaction between the state and its citizens by providing officials with new tools for the operational management of government administration processes and new forms of decision-making support. At first glance, the links between (partially) automated government administration processes and a transformative understanding of government administration may seem limited. However, automated government administration can also be designed to break down silos, which could be a key enabler of transformative government administration practices.

Background: what it's all about

In democracies, public government administration is generally understood, in accordance with the principle of the separation of powers, as government activity that is neither legislative nor judicial.[40] The four government administration resources are: nodality, authority, assets and organisation, each differentiated according to its awareness and effectiveness level (Tan und Crompvoets 2022). Nodality refers to the government's information interface function with citizens (identification and dissemination of information). Authority refers to the legal and official exercise of power in the form of permissions, prohibitions, guarantees and decisions such as judgements. Assets are financial resources and allocable expenditures that governments can use to increase their power (e.g. by influencing other stakeholders, buying data and knowledge, etc.). Organisation means the physical ability to act directly through employees.

Important drivers for the digitalisation of public government administration come from corporate administration. The concept of e-government, referred to as the first era of digital governance (ICT-centred), has been around for more than two decades. It may be followed by a new era of digital governance (data-centred), in which governance is done differently (Tan und Crompvoets 2022). The four government resources can be distinguished here based on information awareness and its impact on society (Tan und Crompvoets 2022): with the assistance of AI-supported big data analyses, for example, the government administration can expand its knowledge advantage on environmental issues and communicate information via Environment Situation Rooms (nodality). The government administration can, for example, detect environmental law violations through remote sensing and ensure compliance through blockchain-encrypted supply chain tracking (authority). The decentralised registration of land ownership and the acquisition/disposal of public land ownership (assets) are both possible using blockchain technology. Data analytics and data protection officers implement data governance in a way that provides stakeholders with continuously updated and verified environmental data (organisation).

The changed role of digital technologies in the exercise of government functions, public added value generation, human resources management and governance can be seen as evidence of this new era of data-centred digital governance.

In contrast to the future topics of Digital Statecraft (Section 2.5) and Legal Tech (Section 2.7), the focus here is primarily on government administration resources: the authority of political institutions and individuals, their assets, the organisation of internal government administration processes and inter-agency cooperation. The resource referred to as nodality, meaning the government administration's interface function with citizens, was examined in Section 2.5, Digital Statecraft, while the resource for the legislative exercise of power was addressed in Section 2.7, Legal Tech.

Drivers and trends

The main drivers and prerequisites for automating government administration processes are the digitalisation of the government administration (e-government), knowledge about the automation of business management processes and the development of digital applications for government administration processes using basic digital technologies such as cloud computing, blockchain and artificial intelligence. The search for new digital solutions for the government administration begins with the flood of data and the growing need to manage this volume and variety of data, including in environmental administration. The digitalisation of documents and processes (e.g. e-files) forms the basis of the new government administration processes. Visions such as State 4.0 rely on digitalisation to modernise the government administration. More and more government administrations are digitally mapping their internal processes, collaborating digitally with other authorities and communicating digitally with citizens, researchers, businesses, environmental associations and other stakeholders.

The increasing use of AI for decision-making support, including decision automation, augmentation and discovery, is driven by crowdsourced citizen data, AI, big data analytics, simulations, collective intelligence systems, participatory e-governance systems, the availability of decision cockpits (including dashboards), and

40 Government administration – Definition | Gabler Wirtschaftslexikon.

a greater understanding of the psychological factors that influence decision-making processes.

Increasingly, market-dominating digital technology companies are taking on responsibilities previously reserved for government agents. Basic provisions and public services, including energy and water supply, transport services, telecommunications, broadcasting, street cleaning, sewage and waste disposal, are being supported or completely replaced by digital services "for all". Consequently, digital platforms are advancing to become basic service infrastructures, and the role of the government administration is also evolving.

Access to more and better data is an important means of achieving the central goal of providing citizen-centred services, reorganising public service delivery and digitalising the government administration (Tan und Crompvoets 2022). In Germany, the Online Access Act (OZG) regulates the expansion of access to government administration services for citizens and businesses. According to the OZG Dashboard[41], as of June 2022, only 80 of the 575 OZG services planned for the end of 2022 were available nationwide. By September 2021, only 58 of the 1532 federal government administration services to be digitalised had been fully and comprehensively implemented online. The sluggish implementation of the digitalisation of federal government administration services is attributed to a lack of digital skills, misplaced priorities and a lack of interest from local authorities. If municipalities used the same software solutions, the software for digital services could be easily adopted by all municipalities connected to an online distribution system with minimal effort. During the adoption process, artificial intelligence systems could assess similarities and any necessary adaptations to specific municipal contexts, thereby reducing the burden on municipal IT experts.[42]

As part of its INNOVA project (Practical Innovation Approaches and Development Paths for a Contemporary Policy for Sustainable Development), which also focuses on digitalisation, the German Environment Agency (UBA) is investigating the drivers and barriers for transformative government administration action. The 2021 department research plan includes a request for proposals for the UBA digitalis project: *Thinking ahead in e-government*[43], and the 2022 edition includes a request for proposals titled "*AI for government administration automation and the detection of criminal activity in carbon trading*". Consequently, public authorities such as the German Environment Agency are making indirect, direct and concrete efforts to research and promote the digitalisation of the government administration.

Emerging issues

The predictive and manipulative power of data analytics and deep learning about individual users and their behaviour, discriminatory political practices through data-driven decision-making, high maintenance costs and failure of automated systems, and

41 The German government is not that digital yet – INSM
42 The German government is not that digital yet – INSM
43 Thinking ahead in e-government – strategy and testing for future government administration action in environmental policy after 2023, including process design for the German Environment Agency's medium-term organisational development (UBA digitalis).

public accountability associated with large data sets and machine learning algorithms are significant challenges for government administration automation (Tan und Crompvoets 2022).

The digitalisation of public services is accompanied by a transformation of the relationship between public service providers and customers and a transformation of work in public government administration (Andersson et al. 2022). A case study of the introduction of a digital automation tool by a Swedish local authority illustrates the complex configuration work required to establish new practices involving technology, materials, discussions, roles and power structures. The authors conclude that these new practices explain why digitalisation can reduce the professional autonomy of public government administration officials and lower service quality.

The technological and regulatory requirements for State 4.0 also need redefining in terms of (horizontal and vertical) collaboration between government agencies. Government administration officials will need to acquire new skills and competencies to decide on IT investments and coordinate the use of automation in decision-making and process execution (Tan und Crompvoets 2022).

The following additional emerging issues can be distinguished:

Service quality: Usability and responsive public services

Automated government administration already has the potential to support responsive public services and simplify existing government administration processes. As part of the automation of government administration, modern, personalised interfaces for citizens to interact with government administration processes (citizen interfaces) are being developed. Examples of digital applications include biometric identification and chatbot communication. In the future, biometric identification may increasingly use facial and DNA recognition. Such applications can go a long way towards regulating a society (cf. the box on biometric identification in India below).

Biometric identification in India

The Indian Digital Identifier is a project that has been running since 2009. It involves collecting biometric information from the entire Indian population (fingerprints from all ten fingers and two iris scans per person). Ninety-two percent of the Indian population has already been covered (Interview 3).

The identifier will be used to obtain welfare benefits. In other words, any support will require clear identification. The challenges are mainly technical: the collection is not particularly accurate. Five percent of decisions are wrong. When the system is not working, people are deprived of their rights. They then have no access to the system, social benefits or food donations. As many of these people depend on food aid, this is of fundamental importance. Some people have already died due to failure of the identifier.

The identifier is also required for bank access and transfers. This has many advantages in a country where direct transfers do not work and where transferring money is otherwise difficult. This means that the identifier is similar to a payment address.

The Indian government commissioned and owns the identifier. It was developed by Indian companies in collaboration with USA and French companies. The digital ID is being exported to Africa (Kenya, Ghana, Morocco, etc.) and (South-East) Asia. The suppliers' aim is to register the entire world population biometrically. The aim is also to create a multinational database that can evolve over time. At present, its capabilities are limited and there is no direct provision of services and products, but cross-data in a wider range opens up new possibilities. However, this also exports the problem of data confidentiality, with the constant risk of data leakage.

Government administration processes should be streamlined and made more efficient through automation and machine learning, especially where citizens interact directly with the government. Examples include the automated completion of forms using previously disclosed information and aggregating related applications.

Public infrastructure is currently one of the least digitalised systems (Jahn et al. 2021). To be responsive to the needs of citizens (responsive government), government institutions need to catch up with the digitalisation of public services in areas such as education, health, water, electricity and digital infrastructure. Digital platform companies such as Google (Alphabet), Amazon, Facebook (Meta Platforms), Apple and Alibaba have the capital reach, market power and access to digital consumers, making them potential trading partners, investors or service providers in the area of public services.

With predictive analytics based on machine learning, it is possible to identify needs earlier and more accurately (Misuraca et al. 2020). The company Cambridge Analytica is an example of this. Applications include predictive policing, predicting epidemics and estimating heating energy demand based on weather forecasts. Predictive analytics can contribute to more efficient use of public resources, help organisations to speed up service delivery and promote a preventative approach (Misuraca et al. 2020). A national (or European) approach to responsive governance is consolidated in the case of international infrastructures.

Position on social scoring and credit systems

Social scoring is a method of evaluating the behaviour of citizens and companies (social scoring) and deriving either negative or positive consequences (social credits). Automated government administration can play a crucial role in this. China introduced a Social Credit System (SCS) in 2014 to regulate the behaviour of all companies, individuals and organisations operating in China. The categorisation of companies, individuals and organisations is based on entries in registers and lists that either reward (redlist) or penalise (blacklist) behaviour. This regulatory instrument has not been implemented nationally by 2020 as planned, as it is not yet fully operational and provincial priorities differ (Jehle 2022). The nature of the SCS suggests that it is part of a broader effort by the Chinese government to enforce rules and regulations (Oswald et al. 2022).

German companies in China are becoming accustomed to the SCS and see both its positive and negative aspects. This type of government regulation contrasts with Europe's autonomous supervisory authorities. There may be conflicts between Chinese data protection regulations and the European General Data Protection Regulation (GDPR) requirements. The SCS's extensive data collection and information asymmetry pose a challenge for businesses. Given the convergence of global trade regulations, the SCS can promote compliance in China comparable to that in the USA or Europe (Jehle 2022).

In Germany, the private sector organisation Schutzgemeinschaft für allgemeine Kreditsicherung (Schufa – the General Credit Protection Agency in English)[44] operates a credit system that helps commercial

44 How to respond to a Schufa entry? | Verbraucherzentrale.de

The Chinese social credit system from the perspective of Bavarian companies

An analysis of 170 Bavarian companies in China found that the majority are on the red (positive) list. Almost nine percent of the companies have received a negative entry in the form of an administrative penalty, which can lead to blacklisting (Oswald et al. 2022).

As the system also applies to Chinese companies, it is believed that the SCS will lead to less corruption and potentially a more level playing field in terms of competition. Perceived disadvantages include adding another layer of bureaucracy and a lack of information about the system and its ongoing evolution (Oswald et al. 2022).

The Chinese authorities do not inform companies about the SCS and its potential consequences, so companies must obtain all relevant information independently. Environmental protection, labour law and occupational health and safety are the areas where the authorities most frequently impose administrative penalties (Oswald et al. 2022).

Most positive entries relate to tax matters, while most negative entries relate to occupational health and safety and environmental regulation violations.

enterprises such as banks, savings banks, mail order companies, department stores, credit card companies and leasing and housing companies to assess the creditworthiness of their customers. Schufa's contractual partners, such as retailers, online merchants, and electricity and telecommunications providers, notify Schufa when a financial claim has not been paid on time and, in return, receive information on whether Schufa is aware of payment problems. A poor score for an individual can result in the denial of a loan or the cancellation of a mobile phone contract. In 2023, individuals will be able to access their personal Schufa data free of charge (Krempl 2022). Thus, Germany has a well-established private sector credit system but no state social rating system to ensure that public-interest-oriented/harmful behaviour is reflected in the form of economic advantages/disadvantages.

The possibility of increased discussion in Europe about modified social scoring and/or social credit systems (probably under a different name) to achieve climate protection goals if other measures fail to persuade individuals to adopt significantly more climate-friendly behaviour cannot be ruled out. The debate on the digital vaccination passport, and thus the potential restriction of freedom of movement to only those who have been vaccinated or have recently recovered, shows that the compatibility of social credits with the democratic political system and the values of the rule of law and freedom is a central point of contention. The questions address the different conceptions of freedom and the fear of societal and individual surveillance. Several ethical, moral and legal concerns remain unanswered. However, voluntary scoring and gamification approaches are also possible. One example is the self-commitment of an ecovillage in the Netherlands to blockchain-monitored ecological footprint scoring.[45]

If transferring the social scoring and social credit approach to applications in the environmental sector, such as the identification of environmental problems and critical behaviour, it is important to note that the algorithms used in this process carry the risk of bias in the machine interpretation and evaluation of the data (digital bias). It is evident that digital biases are often amplified by pattern recognition and unwitting transmission during programming. Similarly, pattern recognition algorithms have the potential to overcome human cognitive biases. The solutions aim for a sensible combination of cognitive and algorithmic

45 RegenVillages or Wild Community EcoVillages – Regenerating People, Land, Culture and Economy

approaches, such as exercises in the form of serious games to raise awareness among developers and users. For a human-centred design of social scoring and social credit systems, how privacy-compliant they are, not only in terms of the shared private data itself but also its interpretation with biases, is crucial to avoid misuse.

Overall, people's reliance on digital scoring and AI systems is increasing here. In addition, while the majority of people in Germany have the technical means to access the internet, there are significant differences in cyberspace digital literacy. This digital literacy divide affects different user groups in different ways and is often exacerbated by misinformation. In any case, there are ethical and legal issues that need clarifying.

If social scoring and social credit systems are designed to be effective and fair while respecting data protection and constitutional law, they could potentially be one of the most extreme means of shaping the relationship between government administrations and citizens and businesses.

Reorganisation of internal government administration processes: Procurement and recruitment

Recent examples of digital applications in government administration discussed include robo-recruitment in human resource management and procurement.

The purpose of robo-recruitment is to increase efficiency and prevent discrimination in hiring or personnel decisions. If robo-recruitment is effective in accessing a wider talent pool, the environment department will be competing with other users of the technology. The environment department will then need to consider how to strategically use robo-recruitment to recruit its own staff in order to continue attracting suitably qualified, motivated and committed employees. AI also enables the prevention of discrimination in recruitment, employee relations and personnel decisions. However, there is a risk that machine-learning-based systems will simply reproduce existing discrimination (O'Neil 2017) or disqualify applicants who are actually suitable based on their CVs.

Automation and AI also have potential in public procurement, for example, to verify compliance with sustainability criteria in purchasing or consumption. However, little attention has been paid to the potential of AI for sustainable procurement, both for public contracting authorities and market participants, and its impact on sustainability.

As the power of algorithms continues to improve, the environment departments may have access to new, effective tools for operational action, sustainable procurement and personnel selection.

Changes in the relationship between citizens and government administration

In addition to the expected benefits, the automation of government administration actions also poses risks to the relationship between citizens and the government administration.

Digital citizenship also means an increase in the number of requests for data and information from the authorities, which requires them to respond more frequently and competently by making data accessible. Customised request portals, AI-assisted logistics and text generation can facilitate the digital response to requests. Actual data transfer rates and other technical limitations suggest an increasing demand for small data.

Machine-learning-based administrative processes work well for high-volume, routine tasks but not for handling individual cases. Legal certainty, for example, in the case of penalty notices, must be guaranteed in all cases (cf. also Section 2.7), so decision-making processes need to involve accountable human beings. Automation increases the risk of bias, which can affect, for example, the assessment of the environmental behaviour of certain social groups.

Transparency and accountability of government administration decisions are necessary but cannot be guaranteed in the case of digital systems that learn statistically. Citizens' interactions with the government administration must be legally certain. In addition, sources of errors in government administrations and responsibilities must remain identifiable to address any liability concerns. On the other hand, sequences of blockchain-secured signature processes and legal transactions offer opportunities for legal protection. However, the focus here is less on administrative efficiency and more on immutability and, thus, protection against the manipulation of government administration processes.

Initially, the transition to automated government administration processes can be time-consuming and error-prone for both government administrations and citizens. Over time, government administration processes may become faster and more efficient. The protection of personal data, including the linking of data sets, must be guaranteed at all levels and for all access points. Access must be guaranteed for all citizens. In other words, there must be no exclusion of parts of the population.[46]

In any case, people must be "involved" in the digitalisation of the government administration. Otherwise, there is a risk of "dehumanisation" of the government administration and the standardisation of people. For example, in the case of standardised administrative documents, the issue of how citizens can interact directly with government administration officials and complain when processes (e.g. applications for environmentally critical projects) take place in real time still needs to be resolved. The use of nudging in government administration is seen as "potentially dangerous" (workshop discussion) due to its manipulative nature.

In addition to the ministries and subordinate authorities of the federal and state governments, such automated government administration processes can also be implemented in the numerous districts and municipalities[47] by integrating the various databases and making the processes traceable. There are new developments and opportunities at each level. Horizontal and vertical networking of government administration entities and their processes is an essential task for simplifying processes and making them more effective and efficient.

However, caution must be exercised when linking administrative databases indiscriminately to protect citizens' privacy and avoid undermining confidence in the government administration. Linking databases on environmental offences with, for example, vehicle registrations or the Youth Welfare Office could lead to unwanted automatic actions such as the withdrawal of driving licences, loss of vehicle registrations and, in the worst case, even the removal of children (Opiela et al. 2019). Loss of control can also occur in data collection or procurement.

The government administration structure – ready for a great transition?

While the first era of digital governance focused on implementing public sector reforms known as New Public Management (NPM), which involved adopting management techniques from the private sector into public administration, new digital technologies in administration are leading to different digital futures. These futures include a new era of digital NPM (integration of digital technologies for greater efficiency and performance, outsourcing public services to private sector providers), a Digital Neo-Weberianism (digital technologies reshape state-citizen interactions, digital public governance within a controlled, closed data ecosystem) or a digital communitarianism (self- and co-governance of the public sector through communities and community-led platforms for managing public decisions and services) (Tan und Crompvoets 2022).

46 It is estimated that 20% of the population suffer from a lack of or insufficient digital resources and skills, particularly those aged between 60 and 70.
47 Addition: with their responsibilities in environmental protection (self-government, delegated responsibilities), including public services, emission control permits, spatial and environmental planning, etc.

Digitalisation and automation are transforming environmental administration, which must also facilitate transitions. In this complex situation, administrations are being reorganised, creating conflict between the decentralisation of government administration and the standardisation of digital processes.

The transition workshop is an additional training format for public government administration officials aimed at strengthening their skills in driving societal transitions (Jacob et al. 2021). Until mid-2024, the INNOVA project will investigate organisational success factors for more transformative government administration actions. The environment department organisations would like to position themselves more strongly as shapers of future sustainability transitions, but their internal structures do not seem to be adequately adapted to this role at the moment. From today's perspective, the reasons for this are as follows:[48]

- Strong fragmentation of transition issues into many small organisational units
- Absorption of the content-strategic transition work by daily operations
- Limited influence of lower levels on transition activities
- Lack of routines for the cross-departmental design of transition policies
- Many employees are satisfied with their role as mere administration officials
- In some cases, only individuals are responsible for transition work

These causes can be translated into design tasks in terms of the personnel, communication channels and decision-making processes required, in which digitalisation also sometimes plays a prominent role. For example, digital collaboration tools and creativity strategies can promote collaboration with other departments. Digital formats can also help with communication with citizens and businesses for greater legitimacy of transition initiatives. Particular emphasis is placed on data analysis capabilities that support evidence-informed and foresight-informed decision-making, greater streamlining of public discourse on transition initiatives through digital applications or visualisations, and the development of transition pathways based on complex digital data and models.

At the same time, digitalisation is changing the **structure of government administration**, accompanied by an organisational transformation. How much of this should be digital, and how much should be human? Does this apply to all levels, including municipalities and regions? What happens if digitalisation and standardisation are poorly executed ("pseudo-digitalisation")? Would everything then have to be "revisited" (new programming, new databases), with the risk that the organisation would have to adapt to the digital environment instead of the technology adapting to the existing organisation and government administration processes (as is currently the case)? Or can the government administration act as a pioneer of digitalisation and become the new model? Practical solutions would be at the EU level: a virtual format for all member states, although this seems a distant possibility. Developing a decentralised, resilient digital infrastructure continues to be a challenge. A decentralised digital structure may be incompatible with other structures (see EU).

Different authorities need to collaborate digitally to coordinate the governance of climate goals. Transition processes require interdepartmental cooperation in research planning (joint programming) and solution development. At the international level, digital processes and data (e.g. environmental data, earth observation data and geopolitical-military data) are a key requirement for coordinating the governance of climate goals. Artificial intelligence can be used to provide services across different authorities, but not all databases can be linked due to privacy concerns.

Departmental differences and inter-institutional competition create bureaucratic silos that slow the pace of transformation (Misuraca et al. 2020). Digitally supported collaboration between government agencies can reduce silo thinking and is essential for the success of transitions. There is a need for organisational

48 Unpublished internal interim report

development and restructuring in government administration and politics to map digital processes and hierarchies differently within the context of a culture of digital transformation and innovation in the public sector. How do different ministries and agencies interact? Who has access to what? This access and these connections occur at multiple levels and need digitally mapped in a legally certain manner. Different government administration agencies must coordinate with each other. This is currently done in a variety of ways, including face-to-face, telephone calls, written correspondence, etc. Nothing would happen without solutions to the various coordination problems (beyond standards) (see accountability).

In terms of concrete environmental research and governance opportunities, digitalisation and AI-supported analysis offer more data management and interpretation possibilities. Much of the data that is currently collected cannot be analysed and, therefore, cannot be used due to capacity constraints. However, high costs and barriers to entry have so far hampered (environmental) research.

Potential implications for environmental research and governance

The digitalisation and possible (partial) automation of specific government administration processes is already a strategic issue on the environment department's agenda. The following implications can be derived from the emerging issues:

- The digitalisation of the government administration is not an end in itself. As a modernisation task, the question is whether and to what extent a New Digital Public Management (integration of digital technology to improve efficiency and performance and delegation of services to private sector parties), a Digital Neo-Weberianism (digital technology in the hands of the state to shape new forms of interaction between the state and citizens) or a digital communitarianism (digital technology in the hands of citizens for self- or co-governance of public tasks) should be implemented.

- Differentiating between the types of AI support for different environmental administration issues could be beneficial, especially in terms of strategic, forward-looking decisions. Transformational challenges and solutions are predominantly global, but global foresight and decision-making systems are rare (global governance systems have not kept pace with global interdependence).

- Digitally supported management of environmental requests within authorities could free up staff and help build consistent and effective external relationships with the requesting parties. The concept of a “digital environmental code”, e.g. with integrated project approval through operationally stored digital processes and documents, could simplify and speed up approval procedures.

- Social credit or scoring systems could be used directly to regulate individual behaviour. Given the totalitarian nature of the SCS in China, a public debate on an SCS in Germany could be challenging. This is evident in the case of the Schufa scheme, which works behind the scenes to assess creditworthiness. The environment department still has to adopt a position in relation to social credit systems, taking into account the opportunities and limitations for promoting environmentally responsible behaviour.

- The potential and challenges of using AI in public procurement, especially for sustainable procurement, have been largely overlooked so far. Digital tools could map public procurement at federal, state and municipality levels and help identify shortcomings and implement sustainability criteria.

- The environment department has a growing need for digital skills. At the same time, human resources management in the environment department has not yet implemented AI-based application and recruitment processes.

- When global companies provide infrastructure and public services data, a national (or European) approach to governance is insufficient. The potential and scope of partnerships with platform companies to achieve environmental policy goals in the area of public services must be explored.

2.7 Legal Tech – digital dispute resolution and adjudication technologies

Trend: Legal tech refers to the increasing digitalisation of legal work, including activities related to environmental law.

Emerging issues:

- The cost-effectiveness and legal certainty of legal tech in environmental law enforcement
- The unintended consequences of legal tech
- Legal tech for reconfiguring law for sustainability transitions

In brief:

- A growing number of individual environmental law cases, judgements and legal reasoning are available digitally, and the demand for mass and preventive dispute resolution is increasing, despite the limited number of lawyers. Against this background, legal tech applications are being developed to combat the "flood of litigation".
- After an initial period of enthusiasm, legal tech applications are increasingly being scrutinised in terms of cost-effectiveness, legal certainty and negative side effects such as discrimination. However, if the specific regulatory and technical limitations can be overcome in the future, legal tech may be used more frequently in environmental law enforcement.
- Using legal tech to identify and assess disputes during transitions could reveal largely untapped potential for a socio-ecological transition. Such use of legal tech could contribute to a reconfiguration of the law for sustainability transitions.

Background: what it's all about

The term "legal tech" is a combination of legal services and technology and refers to the digitalisation of legal work. Legal tech has been researched within the sub-discipline of legal informatics in law for quite some time.[49]

49 Definition: What is legal tech? – legal-tech.de

Legal tech includes digital applications that

- support lawyers in their work (e.g. document management software),
- digital technologies that (partially) automate lawyers' work (e.g. document analysis tools and chatbots),
- digital platforms that connect lawyers with one another and with clients (e.g. lawyer marketplaces) and
- digital legal services that provide access to the law for those seeking legal assistance (including virtual digital assistants).

Legal tech can affect all of these sub-areas to varying degrees. The judiciary consists of constitutional law, ordinary law (voluntary jurisdiction for conflict prevention, civil and criminal jurisdiction) and special law (e.g. administrative law, including environmental administrative law). In Germany, judicial jurisdiction lies with federal and state courts. In addition to the state judiciary, there are independent non-state jurisdictions such as sports courts and ecclesiastical courts. Many legal disputes are settled out of court. In particular, law firms, notaries, legal departments, government administrations and courts are potential users of legal tech.

Drivers and trends

The main drivers of legal tech are advances in digital technologies, given the increasing demand for legal services ("litigation flood", "overburdened courts"), the growing amount of digitally available individual cases, judgements and legal reasoning, the limited number of legal professionals, and new requirements for mass and preventive dispute resolution.

Legal tech promises improved client-lawyer interactions, more effective legal cooperation and time savings in legal work.

Legal tech is a potentially growing area of application for artificial intelligence in (partially) automated adjudication and online dispute resolution. Legal tech is already being used to a significant extent in enforcing consumer rights (fines, air passenger rights, data protection, etc.). In adjudication, legal tech is seen as an assistant rather than a replacement for judges.[50] Other countries, such as Singapore, seem less concerned (Singapore Ministry of Law 2020).

Artificial intelligence can identify human biases, but its algorithms and training data can also introduce its own biases into adjudication and dispute resolution. Legal tech could become an essential component of State 4.0 concepts in a combined form of human and artificial debiasing.

The legal system is evolving as a result of some global trends. Legal services are being affected by the rise of technology companies, trade wars, the rise of Asia, the COVID-19 pandemic and increasing competition in the legal sector. These include the demand for 24/7 availability of legal services, cost pressures on law firms, and the development of in-house legal expertise in technology companies. Promising technological solutions to meet these needs include (Singapore Ministry of Law 2020):

- Enabler technologies: in particular, document management systems
- Back office technologies: efficient case and practice management
- Front-office technologies: support for lawyers in their work (including knowledge management solutions, document authoring software, document analysis software, and so-called eDiscovery software for finding digital documents of any kind, such as emails or database records)
- Legal chatbots for legal advice
- Advanced legal tech solutions that allow lawyers to focus on their core responsibilities
- Online dispute resolution
- E-courts: fully digitalised courts operating in a digital ecosystem with speech-to-text conversion, video-based hearings and meetings, AI-informed

50 Information technology – Judges: No chance for artificial intelligence in the judiciary (t-online.de)

or AI-based decision-making processes and system integration of the various digital services

- Legal cybersecurity solutions as a prerequisite for the success and acceptance of legal practices

The actual use of legal tech on a large scale and in terms of the depth of decision-making influence requires coordinated action by the stakeholders involved and the establishment of government guidelines or leadership. In autocratic states, the use of legal tech is already being planned extensively as an adjudication tool (Singapore Ministry of Law 2020).

AI could also play a role in the detection of environmental crimes if sensors detect certain anomalies (such as pollutants) and automatically report deviations or if AI is used to monitor online trade (e.g. to detect illegal trade in species or other (environmentally) illegal products).

Legal tech is related to CrowdLaw, but unlike CrowdLaw, it focuses on applying existing law rather than creating new law (cf. Section 2.5).

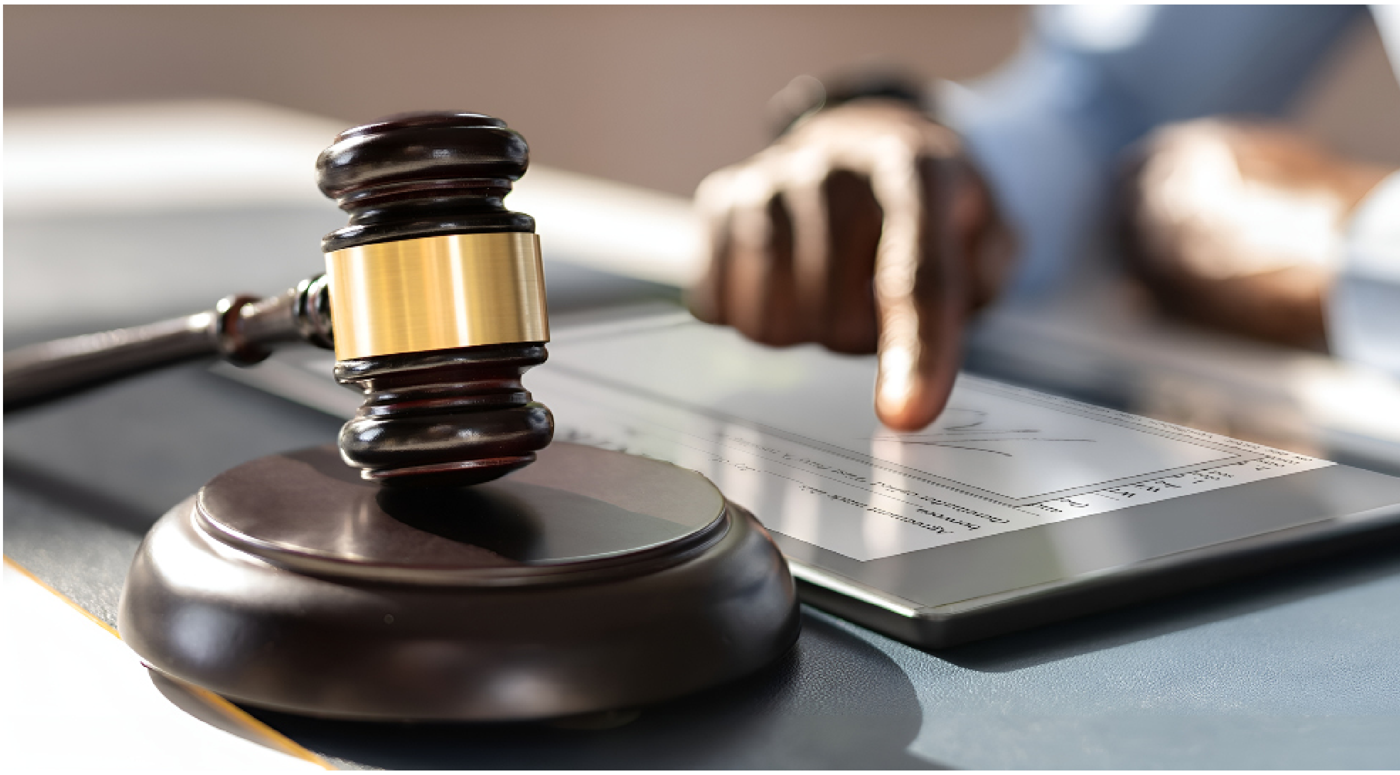
Emerging issues

Together with the German Environment Agency, the environment department is responsible for implementing environmental law in certain areas, such as the German Emissions Trading Authority (DEHSt) and implementing the German Electrical and Electronic Equipment Act (ElektroG). In some areas of law, legal tech can raise new issues, such as in relation to enforcing environmental and consumer protection law and preventive dispute resolution within transition processes.

Cost-effectiveness and legal certainty in law enforcement with legal tech

In many areas of application, the usefulness and impact of legal tech remain questionable. The legal system currently uses artificial intelligence to support the routine activities of lawyers and courts. Legal tech seems less suited to handling complex individual cases (Gigerenzer 2022). While many of the possibilities of legal tech have not yet been exhausted, they often raise serious legal concerns.

Artificial intelligence in conjunction with structured data (e.g. compliance with reporting obligations via smart contracts) and unstructured data (e.g. texts from the local newspaper at the location of the production site) could provide environmental administration with new opportunities to comply with environmental law (see the “(Partially) Automated Administration” future topic). This could potentially



pre-empt judicial decision-making and shift the balance of power towards the executive.

There are also concerns regarding cost-effectiveness, such as the potential for savings in adjudication and the creation of future-oriented jobs in this field of action.

The unintended consequences of legal tech

The use of legal tech is already having an impact on the mass enforcement of consumer protection law. From an environmental perspective, mass enforcement of consumer protection law through legal tech consists mainly of legal action against fines for traffic violations and flight cancellations.[51] Assuming that fines for traffic violations and flight cancellations have a deterrent effect, enforcing consumer rights could potentially further encourage environmentally harmful motorised individual and air travel.

As with other digitally-supported processes, it is particularly important for legal tech, in terms of the rule of law, to prevent the unauthorised appropriation or misuse of information and processes, for example, by litigants or third parties such as digital platform companies. By speeding up and (partially) automating legal work, there is a risk of undermining the rule of law.

Citizens are not yet part of the target audience for the application of legal tech, so they do not have access to information about legal processes. Where legal tech has an impact on them, such as in the enforcement of consumer protection laws, there must be solutions for assessing the outcome of the proceedings and empowering citizens to make their own decisions about the legal situation.

Legal tech to support the reconfiguration of the law for sustainability transitions

The transition processes required by climate protection and other sustainability goals are being driven forward with great urgency. Here, as with any transformation, there are winners and losers. The development of legal frameworks for the great transition is proceeding at a rapid pace and is accompanied by conflicts with other interests. The example of wind turbine siting disputes clearly illustrates this point. Legal tech can support this in two ways.

51 cf. the geblitzt.de and flightright.de portals

From a jurisprudential perspective, legal tech can provide the informational basis for hypothesising about legal certainty and successful out-of-court dispute resolution based on the analysis of a large number of cases related to transitions within specific legal disputes. This requires a critical mass of cases. This legal perspective contrasts sharply with landmark judgements, which are used as precedents in similar cases.

From a legal perspective, the current legal framework is quite restrictive and responsive to new developments. In light of the precautionary principle and the avoidance of unintended consequences, an enabling legal framework that incorporates digital capabilities is required. This includes elements that are innovative, experimental, evaluative and accelerating. Legal tech can contribute to an enabling legal framework by (partially) automating the analysis of a large corpus of legal and administrative documents by scanning, identifying and processing legal practices, barriers and delays within transition processes.

Possible environmental research and governance tasks
With its pre-litigation dispute resolution capabilities, legal tech can be a point of contact for environmental research and governance in transition processes and the adjudication of environmental protection and consumer rights law.

- A key issue for the environment department is how to monitor and support legal compliance through the use of algorithms. This also raises concerns regarding cost-effectiveness, such as potential legislative cost savings and the creation of future-oriented jobs in this field of action.

- The environment department needs to understand the impact of legal tech on enforcing environmental and consumer protection laws. An analysis of unintended side effects and unexpected synergies is necessary before the use of legal tech by the environment department. This requires technology assessment tools with a strong emphasis on a jurisprudential perspective.

- From a legal perspective, the law must be reconfigured to support transitions (acceleration, experimentation, evaluation) by creating incentives to enable new solutions and directions rather than imposing a restrictive framework and merely reacting to ongoing developments.

2.8 Digital Money – new digital currencies and asset forms

Trend: The digitalisation of payment processes and assets is transforming financial systems, which are seen as a key lever for transitions.

Emerging issues:
- Decentralisation and diversification of finance systems
- Governance of finance systems
- Governance of natural capital and trialling local economies

In brief:

- The proliferation of digital payment systems enables the introduction of new digital currencies into existing financial markets or the establishment of entirely new financial markets. Cryptocurrencies and non-fungible tokens (NFTs), the former based on equivalent monetary units and the latter on unique assets, are important avenues for development. These financial instruments, mostly used in the private sector, enable payment traffic beyond the scope of banks subject to government supervision.

- The central banks of some countries and the EU are in the process of introducing sovereign digital currencies to encourage economic agents to continue making payments and investments in forms of money that are under sovereign control.

- Digital currencies are not only a constraint to be taken into consideration by environment departments but also a source of exploitable potential for environmental protection and transformations. NFT-based assetization technologies, which are technologies for (alternative) asset management, have not yet been explored and evaluated in terms of the governance of natural capital or the global commons. Local digital currencies can support the exploration of alternative economic models for a sustainable metabolism.

Background: what it's all about
Digital money is any asset that can be managed, stored and traded digitally.

In the age of digitalisation, traditional payment systems and the banking sector are changing (Ehrenberg-Silies et al. 2022): digital payment methods are increasingly replacing cash payments, making payment processes easier, faster and, above all, more secure. In Germany, internet payment systems such as PayPal are already well established and mobile payment systems like ApplePay are gaining in importance. In addition to established market players such as banks and payment card system providers, innovative IT-focused financial companies from the FinTech sector are also entering the financial market. FinTech companies offer a wide and evolving range of digital applications, from analysing the financial situation of customers to integrated IT solutions for banks and insurance companies.

As digital payment systems become more widespread, opportunities arise for financial market participants to introduce new digital currencies. A currency is a financial unit, such as Bitcoin, that can be exchanged for other currencies, such as euro, at fixed or fluctuating rates. Before the age of digitalisation, issuing currency was exclusively a sovereign task carried out by the state.

There are now several so-called cryptocurrencies that allow trading partners to make digital payments directly, bypassing banks and payment card providers (Best 2021). Many cryptocurrencies are used for payment processing or speculation. The value of so-called stablecoins is backed by pegging them to currencies such as the dollar or gold (World Economic Forum Digital Currency Governance Consortium 2021).

The central banks of various countries and the EU have already introduced or are in the process of introducing sovereign digital currencies (Central Bank Digital Currency, CBDC), where the value of a digital unit of currency is exactly equal to that of a physical unit of currency (principle of equivalence). These sovereign digital currencies are primarily used for payment purposes and not for speculation.

Digital currencies can also support the operation of isolated or local economies with certain incentive systems that may differ from those of the state-regulated national economy. For example, Barcelona wanted to introduce a digital social currency to strengthen the local economy and promote social equity.[52]

Digital assets can be generated through digital activities such as clickworking, online trading or gaming, as well as traditional activities. FinTech companies have developed so-called assetization technologies that facilitate the management of digitally stored assets or valuables (digital assets) for businesses or individuals.

This future topic focuses on digital currencies, including sovereign currencies issued by central banks (World Bank Group 2021), cryptocurrencies, digital investment asset forms and local digital currencies. Cryptocurrencies are typically based on decentralised, peer-to-peer encryption of registry entries using blockchain technology. Newer assetization technologies are based on non-fungible tokens (NFTs),[53] which can be used to securely represent assets (a sort of digital title deed). However, unlike cryptocurrencies (fungible tokens), they cannot be redeemed.

The environmental relevance of digital currencies covers three main areas:

1. Digital currencies can be used to develop, test and operate alternative economies that aim to reduce environmental impacts to some extent.

2. Assetization technologies could be used to register distributed land ownership titles and develop alternative land use governance systems.

3. Finally, environmental research and governance are embedded in economic frameworks and are therefore affected by general developments in digital currencies.

Drivers and trends

The number of cryptocurrencies has grown exponentially in recent years. In total, there are over 7300 cryptocurrencies. In terms of market capitalisation, Bitcoin is followed by Ether, Tether, Ripple and Binance Coin.[54] The increase in value of market-capitalised digital currencies appears to have ended. According to the Gartner Hype Cycle, which places innovation on a curve of rising expectations, the Peak of Inflated Expectations, the Trough of Disillusionment, and the plateau of realistic expectations

52 Digital Cryptocurrency in Barcelona | Z_punkt (z-punkt.de)
53 cf. the ERC-721 (Ethereum Request for Comments 721) standard, a non-fungible token standard that implements an application programming interface (API) for tokens in smart contracts (ERC-721 Non-Fungible Token Standard | ethereum.org).
54 A brief history of digital currencies | Bankstil

(Plateau of Productivity), the previously high expectations of digital currency investors are currently quite deflated. As a result, a period of realistic expectations may follow.

So far, cryptocurrencies have mainly been used for international transactions and purchasing luxury goods (Best 2021). Companies such as Tesla accept cryptocurrencies as a form of payment, which also appear separately on their balance sheets as assets and cash flows. In 2021, high-profile large purchases were made using the digital currency Ether for tweets, columns, avatars and digital art. Payments currently account for less than 2% of the financial volume of blockchain-based financial services (less than 2% of the closed value), which are dominated by lending, decentralised trading (peer-to-peer marketplaces) and asset management (Best 2021).[55]

Governments have different perspectives on cryptocurrencies. These range from watch and wait to ban. The volatility of cryptocurrencies may limit their use in the West. On the other hand, there is huge potential in a number of countries in Africa, South America and Asia, where local currencies are weak or volatile. In June 2021, El Salvador became the first country to officially introduce and recognise cryptocurrencies as legal tender.

After China banned cryptocurrencies (Best 2021), the share of computing capacity dedicated to cryptocurrencies fell from 44% to 0% between May and August 2021. In addition, much of the blockchain mining operations migrated to the USA, which contributed significantly to its share of computing capacity, increasing from 17.7% to 35.4% over the same period. Meanwhile, Kazakhstan's share of computing capacity also increased from 7.4% to 18.1%.

The technical drivers for digital currencies include all the developments that also shape the technology underlying all cryptocurrencies and NFTs – distributed ledger technology (DLT/blockchain)[56] – and the innovative power of the digital financial technology industry. NFT-based "assetization technologies" are among the emerging applications.

Non-fungible tokens (NFTs) are not redeemable, unlike blockchain-based cryptocurrencies (fungible tokens). Fungible means that each unit has the same value. Non-fungible means that each unit has a different value. NFTs can be used as proof of the originality or ownership of a tangible or intangible product (Kind 2022). Therefore, each NFT is unique. NFTs are generated by blockchain, where rights and transactions are stored in the form of smart contracts, almost like a "digital land registry". Moreover, NFTs are of great importance in the fields of art, culture, sports, gaming, fashion and, in the future, the metaverse (see the Metaverse future topic).

Assetization technologies are used to manage the digitally deposited assets of companies or individuals (digital assets). They allow individuals to buy, own and resell shares in assets, e.g. a share of a collectable item, a house or even a piece of land. The principle of "owning a piece of everything" challenges the previously dominant wealth model, which assumes every asset has an owner. In turn, fragmented forms of ownership differ from communal forms of ownership.

In general, the landscape of stakeholders in the digital ecosystem is changing (Ehrenberg-Silies et al. 2022). Digital technology companies and the FinTech industry are developing and marketing technology solutions. In addition, open interfaces (open banking) connect services from different providers. However, cryptocurrencies initially emerged outside the regulated and state-supervised banking and financial sector.

Central banks issue government cryptocurrencies. The planned introduction of the digital euro by the European Central Bank is not a parallel currency to the existing euro but is considered equivalent. Like the physical euro, the digital euro is a sovereign means of payment and is not intended to compete with private sector digital currencies such as cryptocurrencies (World Bank Group 2021). China has also introduced a digital currency (Best 2021).

55 The total electricity consumption of Bitcoin and ether is between that of the UK and Italy. Due to the low proportion of digital payments in blockchain-based financial services, the topic of electricity consumption is better suited to other sectors.
56 Blockchain is a specific type of DLT, much as 3D printing is a specific additive manufacturing process. Often, a specific technology represents a whole family of technologies.

Central banks have only recently emerged as digital currency issuers. During the pandemic, the increase in digital money transfers and payments prompted the European Central Bank to develop a digital euro. This is supposed to ensure that, despite the emergence of digital currencies, people in the euro area continue to have free access to the euro as a simple, widely accepted, secure and reliable means of payment.

In this complex environment, the competitive landscape for traditional private banks is shifting (Carletti et al. 2020). In the USA, seven major banks (including the Bank of America and JP Morgan Chase) and major credit card companies are currently forming alliances to compete with payment systems such as Apple Pay and PayPal by introducing a so-called digital wallet (Nestler 2023). The European Payments Initiative, which aims to create a standard for payments in euro and other currencies, follows a similar approach.[57]

Emerging issues

There are several possible scenarios for the integration of digital currencies into the financial system (Ohse und Michl 2021):

- National currencies 2.0: states use crypto assets for official currencies
- Unconsolidated growth: coexistence of private sector and national currencies
- Cryptomonopoly: one cryptocurrency as a global payment system
- Private sector competition: a variety of private sector cryptocurrencies as a means of payment and financing
- Investment and speculation: cryptocurrencies as decentralised financial instruments
- Ban on cryptocurrencies: financial authorities ban cryptocurrencies, causing markets to dry up

In principle, the hybrid system of cash and cashless payments is expected to continue, but the share of digital payment transactions will increase (Ehrenberg-Silies et al. 2022). Cybercrime remains a concern for blockchain and NFTs (Best 2021).

The decentralisation and diversification of finance systems

With the development of digital currencies and assets, there are new opportunities to diversify and reshape the capabilities of local and global financial systems. In addition to the opportunities, such as facilitating citizens' access to free or low-cost financial services like money transfers or microloans, there are also risks, particularly in terms of data sovereignty and protection.

Parallel structures of social order are emerging as a result of the development of a new type of financial system that could pose a threat to the current social order. State control over financial flows and value creation is declining, and new threats to monetary stability are emerging due to extreme price fluctuations

57 About – European Payments Initiative (epicompany.eu)

in cryptocurrencies, extreme market volatility and speculative bubbles.

In addition, developing digital currencies and financial systems has security and geopolitical implications. Globally, the decentralisation and diversification of currencies are making state control over value creation and monetary stability more difficult, and states continue to respond differently to these developments. The introduction of a digital euro and a digital dollar is an attempt by governments to protect their privileged position and maintain control over payment flows and monetary policy. In this respect, the summits of the leading democratic industrialised countries (G7/G20) could be a suitable arena for the necessary international alliances.

Governance of financial markets

The implementation of market regulations for peer-to-peer payment transactions, market supervision (e.g. access by the German Federal Financial Supervisory Authority (BaFin) to FinTech companies) and the taxation of trading transactions pose challenges for the governance of financial markets in the context of digitalisation, since digital currencies, assetization and transaction mechanisms are not covered by existing regulations. The long-term safeguarding of digital and underlying physical assets and preventing criminal activity are also important objectives.

The new methods of capital accumulation outside established regulatory structures pose challenges for the governance of digital currencies and financial systems and the safeguarding of public finances. Therefore, developing digital currencies and assets is fundamentally relevant to governance issues such as state control of money, transfers, value creation and taxation (of profits/revenues). The European Central Bank's (ECB) activities for the digital euro address these challenges to ensure continued access to free payment means and services in the digital society and appropriate taxation and control in the digital financial world.

In addition, the overall design of structures must be more participatory, as the new, more active involvement of citizens through DLT and digital payment systems is a critical factor in the acceptance and proliferation of digital currencies. This presents an opportunity for the financial sector to become more decentralised and participatory. In turn, this requires new approaches to governance to maintain transparency and government control and to safeguard public assets and taxation.

From this perspective, the digital euro creates a large single economic space for Europe and its external economic relations. A government-accepted online currency can improve the regulation and taxation of

online payments. The governance of markets with taxes, premiums, etc., on digital profits and sales, lack of transparency, and other factors requires rethinking. P2P and cryptocurrency stakeholders are developing their own certification and transaction standards. What should be set up, and how should it be managed?

New methods for the governance of natural capital and testing of sustainable local economies

From an environmental research and governance perspective, the study and development of digital currencies for sustainable applications are crucial. For example, it is possible to use DLT to record environmental use in environmental governance or to use digital currencies for environmental conservation. In addition, using digital currencies and asset forms offers opportunities for transparent, secure and efficient management of environmental use (e.g. emissions trading).

Digital currencies and asset forms provide a range of tools for testing and developing alternative incentive structures and monetary allocation mechanisms in local or otherwise limited economies. The field of digital microfinance services offers potential for sustainability, such as promoting environmentally friendly investments by individuals or small investors or funding initiatives such as living labs that can digitally organise their value creation and transactions.

In the context of governance of the global commons, it would be important to compare and evaluate the existing regime, alternative cooperative solutions, exclusive ownership of large shares by a few stakeholders, digital asset technologies as a new investment model for fragmented ownership, and management as commons (shared ownership with different management regimes). This assessment must focus on the protection of the global commons. The latter would then probably no longer warrant this name.

Possible environmental research and governance tasks

Possible new tasks for environmental research and governance derived from these emerging issues exist in the following three areas:

- Exploration of digital currencies for environmental use beyond emissions certificate and electricity trading: conducting a comprehensive potential analysis study focusing on specific sub-areas would be advisable here;
- Experimental testing of different incentive schemes in laboratories for alternative economies in terms of economic functionality and environmental impact;
- Comparative assessment of assetization technologies, private ownership structures and commons approaches to ecosystem governance;
- Consideration of sovereign digital currencies as a framework for the financial operations of environmental authorities.

2.9 Digital Commons – new cultures and boundaries

Trend: With the proliferation of big data and artificial intelligence, the question of the potential and limitations of digital commons is being raised in a new way.

Emerging issues:
- Conflict between private and public interests
- Digital sovereignty
- Open science
- Stewardship for digital commons
- Alternative economic and social self-perceptions

In brief:

- Digital commons are freely accessible, modifiable and distributable digital resources. As such, they represent an alternative way of organising the economy and society, which is otherwise based on the competing, exclusive use of resources resulting from purchasing ownership or usage rights or special sovereign rights.
- The use of digital commons is well established in the field of research, where research data is made publicly available and methodological transparency is one of the quality standards of science, among other things, to make research reproducible, modifiable and transferable to other research areas. Early and systematic balancing of public and private sector interests is essential for transformative research. Determining which institution is responsible in concrete cases for curating data and algorithms is essential.
- In this context, it is crucial for the environment department to clarify the value of open data and freely accessible algorithm libraries for environmental research and policy and, if the results are positive, to promote general public licences. An audit task can be formulated regarding the form and scope of digital sovereignty for digital commons necessary for environmental protection and how to prevent abuse.

Background: what it's all about

"Digital commons are non-rivalrous and non-exclusive digital resources defined by shared production, maintenance and governance." (European Council 2022) Digital resources include online data, information, culture and knowledge that can be created, modified and distributed as images, audio, text and software, among other digital formats. Free copyright licences protect digital resources as commons.

Commons represent an approach to organising society and the economy that differs from market-based approaches, that focus on prices, and bureaucratic forms of organisation with their hierarchies and executive orders (Rosnay und Stalder 2020). Digital commons are freely accessible, modifiable and distributable. This sub-section focuses on data and algorithms as digital commons made available to the public through digital infrastructures.

Digital commons are not a new topic in their own right. However, the proliferation of big data and artificial intelligence raises the question of the potential and limitations of accessing and using data and algorithms in a new way. Given the urgent and immense sustainability challenges, it is worth taking a fresh look at digital commons as an alternative way of organising society and the economy. Open data, open source, open science and open government also need considering, and their relationship to digital commons must be clarified in the context of environmental research and governance.

Drivers and trends

In recent years, the ever-increasing penetration of digitalisation in the economy and society has been a critical driver for the need to reassess digital commons for environmental research and governance. Data and algorithms have an increasing impact on life.

Societal trends such as the increasing scandalisation of private sector logics (including food waste), the proliferation of collaborative consumption practices (including swapping/sharing/making), and the growing moralisation of markets promote a sense of responsibility for commons – at least in some segments of society.

Civil society stakeholders (including Data Scientists for the Common Good, AlgorithmWatch) and political stakeholders (including the environment department and the EU Commission) increasingly emphasise the public interest in their actions, bringing digital commons more to the fore.

An analysis of the algorithm commons shows that the USA, with its universities and private research labs (including IBM, Bell Labs and the RAND Corporation), was the largest contributor to free software use for all but has lost its leadership in this area to Europe. The proportion of native Europeans involved in creating universally accessible algorithms has increased from just over 30% in the 1960s to 54% in the 2010s. Over the same period, the proportion of European institutions with a contract to develop open-access algorithms increased from 13% to 37% (Thompson et al. 2020).

In the context of citizen science, living labs, open science, and earth and environmental monitoring, there are increasing calls for data to be treated as public goods whenever possible. Algorithms for processing large data sets should also be made available as digital public goods. In addition, free use requires free access to data and skills in using digital data for everyone.

Politicians have recognised the issue of exclusive sovereignty and the use of data and algorithms solely for commercial purposes. A Digital Commons Task Force was established at the Building Europe's Digital Sovereignty conference in February 2022.[58] The EU prioritises open science more than Germany, where the national economy and individual groups benefit more from the private sector exploitation of research results.

Emerging issues

Sovereignty over digital technologies creates balances of power that differ from those in the analogue world. The big technology companies, mainly from the USA and China, have amassed wealth from the interface with users and their data that exceeds the gross domestic product of entire nations. This capital enables them to buy start-ups and unicorns with their innovative power, further consolidating their economic and regulatory power base. Power asymmetries – and thus the risk of abuse of power – exist not only between large technology companies and users but also between state institutions (e.g. intelligence services, the military) and citizens. These power asymmetries are a significant source of tension between different stakeholders.

58 Digital Assembly 2022: A closer look into the digital future (europa.eu)

The power asymmetries are evident in the access to data and the actual opacity of the algorithms (black box). This creates conflict between individuals, private-sector companies and public stakeholders. This relationship exists because, on the one hand, transparency and open access are necessary to enable the optimal use of data (public stakeholders). Nevertheless, there is an interest in secrecy (private individuals), in enabling extensive use for commercial purposes by businesses, and in allowing as many data resources as possible to be used – potentially by everyone – in the public interest.

The conflict between private and public interests

Currently, important data sets are not commons and are only accessible to private sector stakeholders. The main protagonists of the metaverse (cf. Section 2.4) also seem to have an exclusively private approach to data and algorithms. The private sector's appropriation and misuse of digital processes will likely lead to increased efforts at state control. This would mean the legitimacy of commercial or governmental appropriation of data and algorithms being called into question more frequently in the future. As data and algorithms become increasingly important to life, the question of access for all and public interest arises.

The conflict between private and public interests in access to data and algorithms is particularly evident. In the public interest, there is a need to clarify who uses what data for what purpose and who should determine what is in the public interest. Access for all does not necessarily mean that data and algorithms will be used in the public interest. Negative examples include news (e.g. manipulation and dissemination of fake news about climate change, for example), construction manuals (e.g. for additive manufacturing of weapons) and Google Earth (e.g. for identifying natural resources for unsustainable exploitation).

Under the banner of "data for all", discussions are taking place on whether the data of certain stakeholders, e.g. corporations, should be subject to expropriation, sharing or disclosure requirements in the public interest. There is already a wealth of freely available environmental data, and discussions are underway to open up and consolidate additional environmental data sets as this could foster the potential for improvement and innovation in environmental protection.

In the collaborative development of algorithms and software, the identity of participating stakeholders is sometimes unknown, and decision-making mechanisms are not obvious, as evidenced by open-source software development or the collaborative storage and management of software code in the cloud (e.g. the web-based GitHub service).[59] Digital commons communities play an important role in identifying and addressing security vulnerabilities in digital systems.

Donations of data and algorithms could be one way to build public data sets. This will require the right incentives.

Digital sovereignty

The issue of digital commons is currently being discussed in the political sphere from the perspective of digital sovereignty. The "Declaration by the Presidency of the Council of the European Union calling for a European Initiative for Digital Commons" cites Wikipedia, Linux, OpenStreetMap and Open Food Facts as notable examples of digital commons. Such digital commons would improve the control and use of data and the security of digital tools and innovations, challenging the isolationist strategies of certain governments and digital service providers. Digital commons would be a powerful tool to establish multilevel governance of our data and digital tools, and thus regain some digital independence. The French Presidency of the EU has set an objective of using open-source solutions and digital commons in a significant number of requests for proposals. The objectives are to Europeanise national digital commons and open-source software activities, promote their use at the EU and Member State level, and provide a framework for participation in strategic digital commons through funding and expertise. If no binding rules are established for the provision of digital commons, no digital sovereignty in the sense of control can be achieved despite selective sharing.

59 cf. Algorithms Working Group | MLCommons, What the Future of Open Source Software Will Look Like | HackerNoon and the GitHub OpenSearch project "ml-commons provides a set of common machine learning algorithms, e.g. k-means, or linear regression, to help developers build ML related features within OpenSearch."

Open science

The concept of open science encompasses open access, open data and open collaboration. Key challenges in the area of open science include awareness, information and knowledge, positive and negative incentives for researchers, and frameworks, investments and skills.

In research, it is expected that data will increasingly be shared globally. The data will need to be anonymised or processed under strict protocols, such as those used by statistical offices. There will be efforts to make the data sets held by tech companies available to the general public, at least in some form, for non-commercial purposes. For public relations purposes at a minimum, it is highly likely that tech companies will make data available to researchers. It is unclear whether researchers, civil society, tech companies or governments will take the initiative in this regard (Interview 3).

The Rathenau Institute has developed four scenarios for open science in the areas of defence, growth, prosperity and missions, differentiating European strategies and implications for productivity, quality and society (Hessels et al. 2021)[60].

The Rathenau report formulates five policy directions that would prove productive in all four scenarios:

- Creating a distinctive profile for European science based on European public values
- Coordinating investments in data standardisation and data curation capacity
- Investing in quality control to verify and certify the data quality of research from other regions
- Further developing and promoting new ways to create incentives and recognition schemes for scientists and contributing to open science.
- Encouraging open collaboration with a variety of scientific partners from the private and public sectors.

60 In a defence scenario, open collaboration would be limited to Europe (1). A growth scenario contrasts open collaboration with limited access to research results (2). In a missions scenario, open science contributes to addressing European challenges (including the Green Deal) and strengthens European integration (3). In a prosperity scenario, data sharing, open collaboration and non-exclusive use of research results dominate (4).

Stewardship for digital commons

The demand for the availability of data and algorithms – in the sense of a digital public good – creates new tasks for national and international authorities and institutions: data in the public interest must be collected, managed and made available to the public. In addition, algorithms need to be collected, checked for quality, consistency and security, and organised for potential use by all. In the public interest, the social and environmental sustainability of data storage and processing should be considered and optimised.

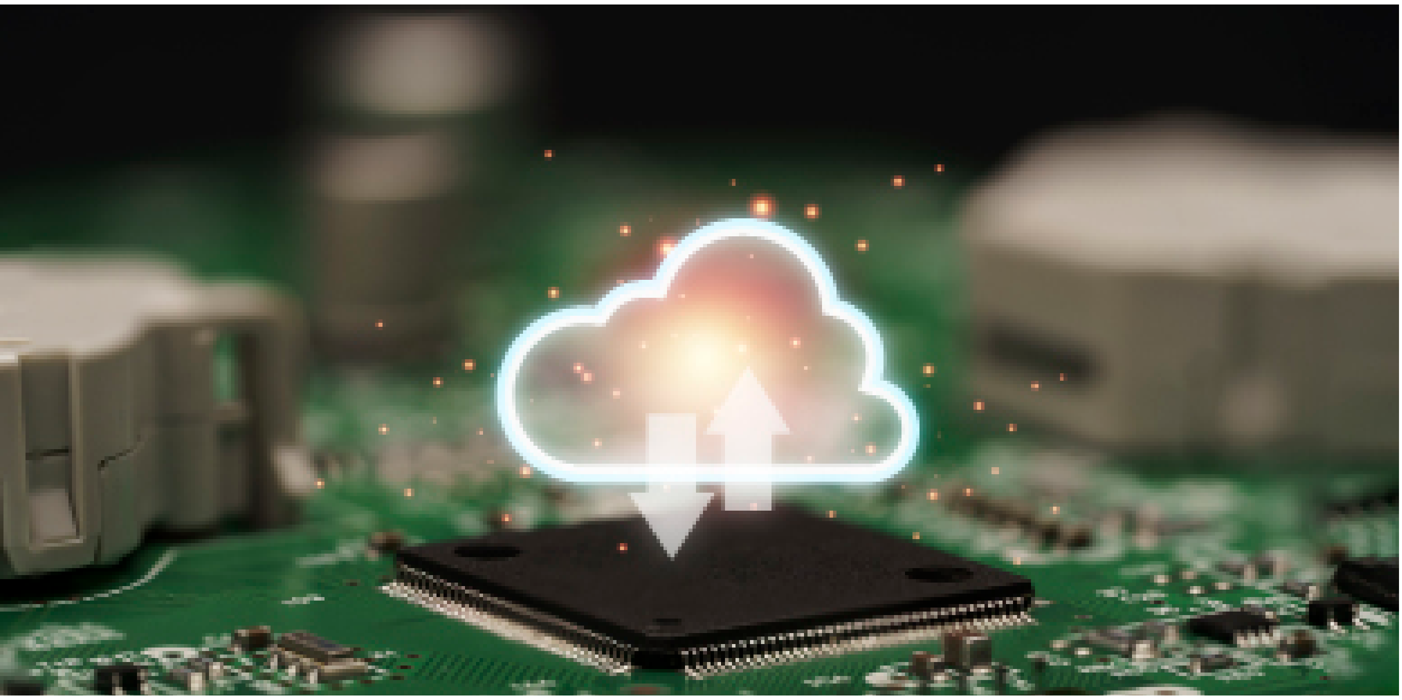
Strong, independent institutions are needed to balance the interests of data access and use ("data brokers"). However, these institutions have to contend with the challenge that global corporations collect the data, while regulation takes place mainly at the national or European level. The question arises as to how the balance of power will evolve in the future and how to balance public, individual and private sector interests.

Any form of stewardship for digital commons aims to protect, secure and safeguard the independence and quality of the collective data sets, algorithms and infrastructures. The debate about the state's responsibility for digital commons involves the establishment of standards on the one hand and the curation, maintenance and protection of data on the other:

- Could and should the state take on these functions, or is it preferable for stakeholders to handle them?
- Is there a need for a solid and independent data advocacy institute?
- Is it possible to achieve collective responsibility for the curating, maintaining and safeguarding of digital commons?

Alternative economic and social self-perceptions

The digital space is filled with unlicensed and Creative Commons-licensed creative activities, products and content that emerge from the fusion of cultures and styles, music and food, ideas and games, information and insights. These are also driven by widespread access to proprietary digital platforms. Digital commons enhance legitimacy, expand the realm of possibilities and accelerate fluidity. This creativity is leading to a decline in traditional, often self-limiting identities. Instead, people seek out new content, products and activities, adopting fluid identities, in terms of gender or beliefs, for example, and forming new groups that share these transitional identities. This requires the transformation of individual identities into collective identities, which in turn are differentiated from other identities. At present, both environmental protection groups and groups sceptical or hostile to environmentalism have relatively rigid



identities, which clash with the equally rigid new collective identities around environmental protection that have emerged out of this fluidity (Interview 3).

Digital commons are also being used for commercial and public-interest-oriented purposes in the private sector and civil society. Companies are coming together under banners such as “Data Commons for Sustainability” to access shared resources for carbon accounting, digital product passports and European Green Deal (EGD) reporting. The focus is on access to highly detailed, up-to-date primary data at product and material levels across value chains. Interoperable and secure cross-industry standards for data exchange, the so-called data commons, are intended to help. Of course, the challenges of creating incentives and preventing free-riding also apply here. Furthermore, it seems important to clarify whether the participating companies and the research community and society as a whole should have access to this primary data. This could, for example, be used to minimise private carbon footprints.

Companies can be founded using digital codes (Bigelow 2020; Hase 2020) and promote fluid entrepreneurship by speeding up and professionalising processes (Interview 5). Initiatives such as AI for Good are already using case studies to investigate the success factors for the longevity and public interest impact of a wide range of social and commercial projects and initiatives (Siebold et al. 2022).

Overall, the various uses of digital commons point to a spill-over of principles into analogue life. This is already reflected in initiatives such as food sharing and bookshelves but could be extended to other areas.[61] However, caution is required regarding naive and altruistic expectations of contributions to the digital commons.

Implications for environmental research and governance

The environment department is not unfamiliar with concepts such as open data and open science, but they may need re-evaluating in light of changes in the public sphere and research.

- Transition research often overlooks the conflict between private sector and public interests. If not required by law, an early and systematic balancing of public and private sector interests is essential for transformative research.

- Conflicts between groups with fluid or pro-environmental identities and groups with rigid identities that are sceptical or hostile to environmental protection are of interest to the environment department. The stakeholders involved, their identities, arguments and scope for action need identifying in relation to environmental tasks, conflicts and problems to open up transformative environmental governance.

- In this context, it is crucial for the environment department to clarify the value of open data and freely accessible algorithm libraries for environmental research and policy and, if the results are positive, to promote general public licences. Promoting digital commons in the environmental sector (research, education, etc.) is suggested, as both have the character of commons and can thus create alliances and synergies between the stakeholders involved. In particular, the EU digital commons policy should be monitored and evaluated in terms of the extent to which it promotes digital sovereignty and to what extent it is linked to the European Green Deal. This can be used to formulate an audit task for the environment department regarding the form and scope of digital sovereignty for digital commons necessary for environmental protection and how to prevent abuse.

- Alternative options need to be considered here, such as whether the collective data sets should be curated by an independent institution, supported by the state (e.g. financial funding versus independence), or managed by the state. As a provider, the environment department would need to ensure the curation of data and algorithms. In contrast, as a user, it would need to engage systematically and effectively in the reframing of data and algorithms within environmental research and governance. In any case, storing environmental research data in the most socially and environmentally responsible way possible is essential.

61 When we share, everyone wins – Creative Commons

2.10 Digital Evidence – are data, algorithms and digital tools driving a new style of research and policy?

Trend: Digital resources are increasingly used as evidence in research and policy.

Emerging issues:

- Knowledge value, added value and the limits of data-intensive research
- Added value and limitations of automated research management
- Added value, significance and limits of evidence-informed policy decision-making
- Digital literacy

In brief:

- Digital applications can effectively support evidence functions within a purpose-oriented policy style. These functions include identifying problems and possible solutions, organising collaboration and building consensus, initiating behavioural changes and gathering feedback. At the same time, the limitations of digital evidence for changing complex systems and epistemising politics are criticised.

- A policy style based on digital evidence relies on the digital tools and infrastructures of companies such as Microsoft and Alphabet and, thus, on the algorithms and data governance provisions embedded in them. The informational value and vulnerability of digital evidence must be considered critically, including in research management, using data, algorithms and digital tools, and requires appropriate digital literacy in environmental research and governance.

- Given the dynamics of development and sudden breakthroughs in the performance of digital applications, continuous and early recognition of the potential of new digital tools for environmental research and governance should be considered.

Background: what it's all about

Evidence serves several purposes in the policy cycle (Cartas et al. 2022): identifying problems, understanding causal relationships, identifying policy options, simulating the impact of options, developing and modifying the preferred option, gaining approval, organising collaboration, initiating behavioural changes, monitoring implementation, collecting feedback, analysing data and gathering evidence. Digital technologies and their applications can effectively support many of these evidence functions within a purposeful policy style.

It is precisely this evidence-informed policy style that has recently come under increasing criticism. A major line of criticism is linked to the distinction between complication and complexity (Korte et al. 2022b). While it is generally feasible to act rationally in a complicated and opaque decision-making situation based on comprehensive information and system knowledge (e.g. in the form of causal cause-and-effect analyses), decision-making situations in complex dynamic systems typically lead to unpredictable developments. As a result, if digital environmental research and governance apply complex systems rather than only complicated ones, improving the information situation and system knowledge does not result in better achievement of the desired goals. In this scenario, the emphasis should be on appropriate heuristic rules rather than more data, information or knowledge (Korte et al. 2022a).

A second line of criticism relates to the observation that scientific evidence contributes to an epistemising of politics, which threatens democracy by implying that certain policy implications should be derived from scientific consensus (Bogner 2021). However, political action is fundamentally concerned with undecidable challenges that require participants to tolerate ambiguity (Bauer 2018). Administrative action, on the other hand, involves decidable challenges that lead to comparable consequences for similar cases within a given framework. According to this interpretation, digital evidence can inform decision-making processes but cannot fundamentally replace the deliberative processes that are essential to a democracy (Bogner 2021).

During the COVID-19 pandemic, the different roles **of science** (presenting the facts and decision options) **and politics** (making decisions based on the facts) became more visible to the general public. Politicians argued that they should follow the science and pursue evidence-based policy. However, the scientific community often disagreed on their assessment of the various options, citing the multiplicity of measures. Individual scientists called for the formulation of policy objectives in order to develop compatible decision-making options. However, the COVID-19 pandemic demonstrated that policymakers had to repeatedly redefine the parameters for decision-making and, contrary to the narrative, had to make decisions without always relying on science. Individual scientists made recommendations based on their specialist perspective (e.g. epidemiology), whereas policy-makers had to consider and involve other perspectives in their decision-making, such as the social impact of a lockdown on children. Many scientists did not want to make recommendations but to provide the information base for value-based policy decisions. In addition, it was unclear which types of knowledge policy-makers prioritised and how governments synthesised different types of evidence. Overall, there is a significant need for clarification of what evidence-based policy actually means and how the relationship between science and policy should be structured within it (Atkinson 2022).

Digitalisation influences how policies are developed and implemented for science, research and innovation. This diagnosis raises the issue of what **role digitally generated knowledge will play in future political processes** and what role digital tools and algorithms could play in knowledge synthesis. These processes require appropriate platforms, such as data platforms and innovation platforms. Data platforms support access to and synthesising of data, while innovation platforms support policy design with data ecosystems, knowledge management tools and specialised simulation software (e.g. to test the impact of different measures and the consistency of policy packages). Both platform types can also exist in hybrid form (Klobasa et al. 2021).

Data has always been an essential part of empirical research. Data is typically used to observe actual conditions and to validate theories empirically. **Data-driven research** is emerging as a new style of research that largely dispenses with the falsification of theories. Environmental research has long been data-intensive and a pioneer in data analysis. However, new challenges are also emerging here, not only in the amount of data but also in the variety, speed and nature of data collection, analysis and preparation for policy processes.

Drivers and trends

In its “Data Strategy: An innovation strategy for social progress and sustainable growth” (Bundesregierung 2021), the German Federal Government identifies four areas of action: effective and sustainable data infrastructures, innovative and responsible data use, improving data skills and establishing a data culture, and making the state a pioneer. Numerous policy papers promote the evidence-based policy style.

Technical drivers are big data, artificial intelligence, digital platforms and the establishment of long-term digital research infrastructures (including the National Research Data Infrastructure (NFDI), centrally aggregated structured environmental data, mission-oriented research infrastructures, e.g. for the Twin Transition, European Open Science Cloud (EOSC)), emerging data ecosystems with a variety of data sets from the different private sector, private and public stakeholders, and applications such as semi-automated indexing of internet content. "Recently, Open AI's chatbot ChatGPT has caused quite a stir, having been trained with big data to answer virtually any query, create artefacts such as text and images, and act as a dialogue partner with users to reflexively and iteratively increase their understanding of their epistemic interest. Unlike its human counterparts, the chatbot is always available as a dialogue partner unless the associated infrastructure is overloaded.

The availability of large databases, the increase in computing power and the spread of new statistical methods are transforming scientific practice and accelerating the consolidation of epistemic issues in data science (Martinez 2021).

The changing relationship between science and politics, the perceived discrepancy between data availability, its use in the public interest, and data donations and citizen participation in research projects (crowdsourcing, living labs, etc.; cf. the Digital State future topic) are social drivers.

Overall, digitalisation affects the entire research cycle and the entire governance cycle.

Emerging issues

The environmental sector may continue to be at the forefront of intensive data-driven research in the future. Large data sets (e.g. Copernicus data from the European Environment Agency) are already in the public domain and offer enormous potential for environmental research. New approaches such as Gaia X could make a significant contribution. In many cases, data protection law aspects are less problematic in the environmental sector than in other areas and have already been clarified. Data could be a game changer for evidence-informed policy (Sancho et al. 2022).

The strengths and weaknesses of big data analyses for environmental protection should be compared with those of other research approaches. The results of big data analyses should be used for environmental protection while complying with data protection requirements. Digitalisation is transforming global governance, and the specific areas of potential for environmental governance need to be identified, assessed, and, where appropriate, implemented.

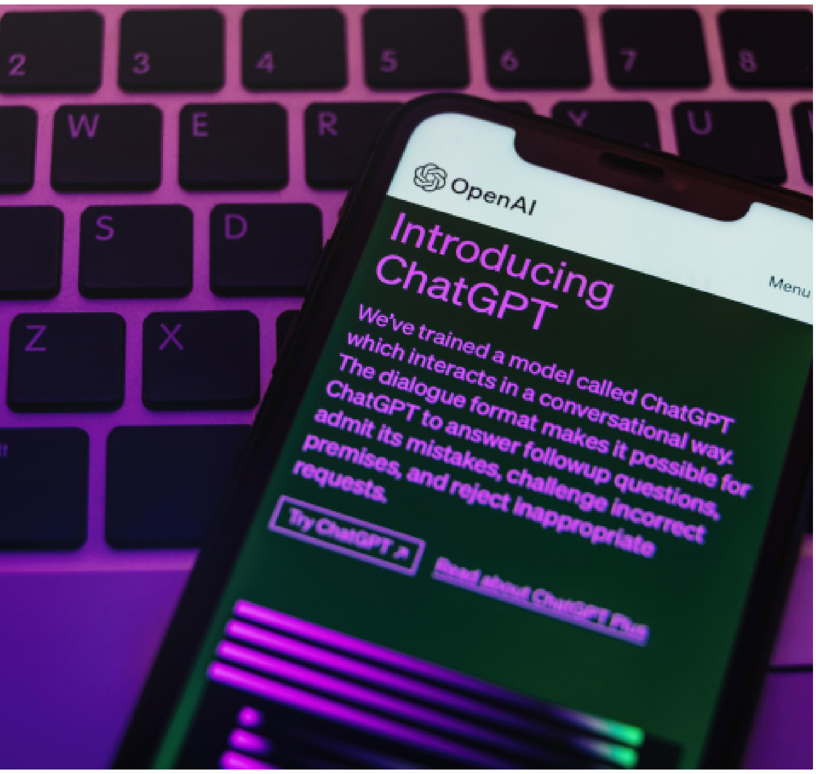
Research is becoming increasingly digital at both programme and project levels. As a result, the relationship between different forms of knowledge is being reassessed and renegotiated.

Knowledge value, added value and the limits of data-intensive research

The expansion of data infrastructures for environmental and other data for scientific use is progressing. At the same time, environmental research is becoming more accessible to statistical evaluation and forecasting of environmental data. This raises the question of the importance of digitally generated environmental knowledge. Over time, databases will increasingly be linked across scales and time periods, with models and interfaces through which new data is input and processed for the database (Interview 3).

Digitally generated knowledge from big data, e.g. through data mining in hybrid datasets or machine learning, has an independent quality that is often difficult to understand and does not necessarily meet the requirements for mapping the complexity of environmental knowledge. The predictive power of machine learning models and trust in digitally generated knowledge are crucial for the evaluation of digitally generated knowledge. Such knowledge-by-design ("at the push of a button") no longer meets traditional scientific standards in terms of hermeneutic quality, causal explanation and falsifiability.[62]

62 Theory-driven and data-driven analysis are two essential scientific procedures. In the theory-driven method, a hypothesis is formulated and tested against predetermined cause-and-effect relationships. In the data-driven method, data is first analysed to identify patterns, which can then be used as a basis for formulating theories. By temporarily abandoning theories, data-driven methods generate quasi-teleological explanations that can be used to formulate a theory through inductive and abductive reasoning (Martinez 2021).



Small data refers to small amounts of data that are just large enough (or small enough) to be accessible for analysis and usable for actionable information within the context of a particular application. Methodological approaches are used here to draw conclusions about larger phenomena from a small amount of data. This approach may gain traction in Europe and Germany due to data protection concerns and the associated limited data availability. Small data could also serve as training data for algorithms. However, there is debate about which methods are suitable for filling data gaps in which cases, while their software-based implementation is becoming easier.

With the advent of quantum computing, our worldview has the potential to change even further. Traditional computers solve problems by trial and error until they find the right solution. Quantum computers, on the other hand, test all possible paths simultaneously. They use quantum bits, or “qubits” for short, instead of binary “bits” (0) and (1). These qubits exist in a superposition state that collapses on observation. If quantum computers play a significant role in society, the underlying physical principles of quantum computing are expected to also shape our worldview as metaphors. For example, we now talk about something “being in our DNA” to refer to our immutable characteristics. Or, we say “my hard drive has been wiped”, meaning we have forgotten something. In a widespread understanding of quantum physics principles, knowledge of the world is no longer limited to capturing a single true state but is based on the simultaneous overlap of different perspectives without empirical observability (Interview 2).

The quality of new creations through digital algorithms is controversial and contrasts with the creative act performed by humans. Initial experience with ChatGPT suggests that people use the chatbot as an interactive companion in such a way that their reflection on a topic evolves as the conversation progresses. The chatbot’s capabilities also include (when skilfully prompted) visualisation, stimulation of human interaction, and the preparation of target-group-specific texts of a desired length. In general, digitalisation is changing the culture of work, bringing with it some benefits such as time savings, stimulation of creativity and reflection, but also a lack of personal understanding of issues and reduced attention and commitment.

The emergence of digitally generated knowledge and the associated changes in the knowledge system indicate the need to ensure the diversity of perspectives and forms of knowledge (digitally generated knowledge, traditional science, practical knowledge, indigenous knowledge, etc.).

Interdisciplinary and transdisciplinary research is increasingly exploring changes in human-technology-environment relationships and using them as a starting point for transformative research, with the digitalised society itself becoming the object of study. At the same time, research is becoming increasingly digital at both programme and project levels. As a result, the relationship between different forms of knowledge is being reassessed and renegotiated.

The research cycle consists of initiating, completing and exploiting research at both project and programme levels. The main focus here is on conducting research projects using new data-driven technologies.

Automated indexing of internet content can be used to rapidly generate knowledge syntheses as a starting point for (environmental) research.

With regard to environmental research, different types of real-world understanding can be distinguished, such as:[63]

Interpreting data as an indicator of reality in the absence of a model of reality. Machine learning observes patterns and reduces them to essential variables relevant to decision-making, which can be used to support model building. This is state-of-the-art technology today.

There is sufficient information about aspects of reality to translate them into digital representations of reality (digital twins). Digital twins can be used to map the effects of hypothetical changes to reality for controlled environments. This is now cutting-edge science in some areas.

People's views are represented in models of reality. Emotion recognition can be used to infer human intentions, while human-machine interfaces can directly read neural impulses as indicators of human intentions. With the integration of quantum technologies, this seems feasible in the long term.

In research, data-intensive processes promise a more precise understanding of situations by incorporating and combining vast amounts of data from different fields of knowledge. In reality, this also involves linking data that was previously unlinked for privacy reasons. In machine learning, predictive accuracy is often used as a measure of quality without necessarily requiring causal explanations. To realistically assess the consequences of actions, having access to better-quality data is often more important than having more data. Access to data by foreign stakeholders is often viewed with scepticism, but it is essential in the case of cross-border environmental issues. Sometimes inconsistent data is used, and it's not clear whether and how it was curated and quality-checked.

Digitally generated knowledge, e.g. through data mining in hybrid datasets or machine learning, has an independent quality that is often difficult to understand and does not necessarily meet the requirements for mapping the complexity of environmental knowledge. The predictive power of machine learning models and confidence in digitally generated knowledge are crucial for evaluating digitally generated knowledge. Such knowledge-by-design ("at the push of a button") no longer meets traditional scientific standards in terms of hermeneutic quality, causal explanation and falsifiability.

63 cf. S&T&I for 2050 | Futures4Europe and Erdmann et al. (2022)

If these trends continue, computer science will become the dominant discipline (data science, digital humanities, etc.) with implications for environmental research. The reductionist perspective of environmental problems through digitally generated knowledge has implications for how these problems are perceived, formulated and addressed. As the emphasis in environmental and social research shifts from traditionally generated scientific knowledge to statistically generated digital knowledge that claims to be predictive, a strategy must be developed to address this change.

At the same time, the question arises as to which areas of research should be worked on with statistically generated digital knowledge and which should continue to be worked on using qualitative methods, causal models and hypothesis testing – and what role the former should play for the latter (e.g. the generation of non-predictive hypotheses for further investigation with traditional scientific methods). Qualitative research and other types of research are under pressure to justify their legitimacy in the face of the enormous "truth promises" offered by data-intensive research. There are limits to the availability of suitable data to address major social challenges, and real-world adaptive control of social processes based on predictive data is still a long way off. Consequently, generating knowledge about causal relationships and impact mechanisms remains a fundamental aspect of environmental research that needs to be refined, expanded and safeguarded.

Digitalisation has also led to disillusionment with softer forms of knowledge. Especially in terms of creativity in online workshops and the anticipation ability of algorithms, digital formats do not seem to have lived up to expectations so far. The quality of new creations through digital algorithms is controversial and contrasts with the creative act performed by humans. In general, digitalisation is changing the culture of work, bringing with it some benefits and reduced attention and commitment. Currently, emotion recognition helps to identify human intentions. Long-term additions could include human-brain interface strategies. This can be used for a variety of purposes, but it can also be abused. It is unlikely that transformative research will benefit more than average from these possibilities.

The emergence of digitally generated knowledge and the associated changes in the knowledge system indicate the need to ensure the diversity of perspectives and forms of knowledge (digitally generated knowledge, traditional science, practical knowledge, and indigenous knowledge, etc.).

In data-intensive research, algorithms with biasing and debiasing capabilities are essential for accurate results. In particular, this includes considering human biases that can be uncovered by AI (e.g. the availability heuristic (Schirrmeister et al. 2019)) and AI biases that can be uncovered by humans (e.g. learned biases based on inappropriate training data). Bias refers to systematic unreflected distortions in the interpretation and evaluation of data. Biases can also be caused by random errors, such as programming errors, that lead to misjudgements or discriminations. It can be assumed that, in the medium term, a state of research will emerge that includes both components, human and machine bias. Serious games can also help to raise awareness among developers and users.

Added value and limitations of automated research management

Research management, like research itself, uses data-intensive processes.

Research institutions and ministries can better identify research gaps through (partially) automated research reviews. In most cases, web scraping, text mining and topic modelling are used to construct images of research topics based on the statistical frequency of terms and term combinations, sometimes over time. Systematic research reviews (re-)produce knowledge from different types of studies, descriptive data and mapping and reveal knowledge gaps and patterns.

Ministries use (semi-)automated research reviews to identify topics and reduce review effort. The National Science Foundation in the USA is currently investing in automated research proposal review. Research institutions use (semi-)automated research reviews to monitor the submission of topics for proposals or publications. Even today, applicants are already thinking about their proposals in terms of how they meet the terms and expectations of the tendering institutions. Creativity and originality may be lost when AI is used extensively in requests for proposals and research proposals.

The same statements regarding the automation of government administration (see the Legal Tech future topic) apply for the management of research programmes and their associated research projects.

Measuring the impact of research programmes, for example, in terms of sustainability, sovereignty or resilience, presents a number of systematic challenges.[64] Firstly, these include non-linearities due to interactions within and between different research projects. Secondly, there is the issue of attribution because additional conditions must be met for research results to be widely disseminated and have a corresponding impact at the macro level. The third issue is the ex-ante problem, which arises because the effects occur on different time scales with different delays and, therefore, cannot be extracted directly from ex-post or concurrent monitoring.

Machine learning for impact evaluation of research programmes can potentially address non-linearities and the attribution problem, but not the ex-ante problem. This would allow meaningful conclusions to be drawn about the design of research projects and programmes and their embedding in wider contexts. Anticipatory governance tools, including horizon scanning and online deliberative platforms, would continue to be available to address the ongoing ex-ante problem.

Added value, significance and limits of evidence-informed policy decision-making

In general, scientific advisors do not usually receive feedback from policy decision-makers on whether their advice had an impact on decisions or how those decisions were made. Decision-makers tend to focus on dominant discourses and value the opinions of trusted contacts within the scientific community. In essence, the question is what constitutes evidence and what kind of evidence is most valued.

Policy advice should generally be reliable, neutral, legitimate and accessible to the public. Scientists must accept their role as **honest brokers**, developing politically impartial policy options and assessing their implications. The role of **foresight** in the policy process is to analyse evidence-based policy options within their broader social context and anticipate how

stakeholders might be affected by the policies under consideration. While evidence informs policy and society about what is reliable, true or false, foresight has a complementary and broader function than scientific evidence (van Woensel 2021).

Data-driven evidence requires complex techniques for selecting and weighting data. Tying policy to the scientific findings would be a technocratic attack on democratic accountability. This is why evidence-based policy is now being replaced by evidence-informed policy, which promotes empirical evidence as the information basis (Atkinson 2022).

(Maffei et al. 2020) distinguish three scenarios of data-driven anticipatory governance:

- The policy dashboard scenario: data-driven anticipatory governance within a government
- The data collaboration scenario: public-private partnerships for data-driven anticipatory governance.

64 In addition, the systemic nature of transitions and the need for coordination with other departments and sustainability stakeholders limits the ability to isolate impacts.

- The collective imagination scenario: data-driven anticipatory governance with citizens.

While the policy dashboard scenario could become a reality within an automated government administration (cf. Section 2.6), the data collaboration and collective imagination scenarios are more likely to be found in future topic 2.5, Digital Statecraft. The added value, legitimacy and effectiveness of data-driven policy processes can be defined differently depending on the scenario.

Digital research and innovation policy (digitalisation of science and innovation policy – DSIP) initiatives are increasingly being pursued as alternatives to deliberative or administrative approaches. Semantic technologies are being used to develop these research programmes. Access to all relevant digitally encoded sources from private, private sector, civil society and public stakeholders is a prerequisite for considering all relevant sources.

API interfaces do not exist for all relevant sources or are not considered by service providers. As a result, service providers like NEWS-API determine the digital population, which may follow different rationales than the knowledge interests of research and innovation policy. Specialised scraping bots can at least select the digital resources available on the internet via the dynamically evolving term systems stored in them. This data is often deliberately not made available for scraping and subsequent exploitation, which raises legal concerns.

Automated information processing and presentation can support policy processes.[65] Translating environmental research into policy measures and evaluating its effectiveness is becoming increasingly complex. It is also becoming more urgent in the face of ambitious climate goals. For example, there is a database on sustainable land use management practices that contains over 7000 entries. Algorithms and machine learning are increasingly used to select appropriate environmental policy measures or plan investments. Specifically, machine learning approaches are being used to automate the screening, selection and ex-ante evaluation of possible measures.

Using key performance indicators (Sancho et al. 2022), case studies for data-intensive policy-making explore their potential and limitations, such as a collective data-driven analysis to validate an existing anti-radicalisation policy (based on a participatory review of social media and open data) and an analysis for a smart agricultural policy.

The evaluation of (environmental) governance using machine learning concerns assessing the extent to which the intended goals are actually achieved. For some goals, there are indicators that can be collected and evaluated using structured data. However, especially for softer goals, such as the achievement of normative ethical claims, the analysis of unstructured data with sentiment analysis, in other words, the statistical evaluation of emotionally charged terms, seems to be a more viable strategy.

Some argue that science is facing a crisis of credibility. Disagreement regarding scientific facts, analyses, and expert opinions would erode societal trust. One reason for this is the challenge that automated processes and simulations could become less and less understandable to the users of the information (epistemic opacity). In contrast, a vibrant and diverse scientific culture is seen as essential for addressing social challenges. In science, data must be open and reproducible. However, a similar understanding of open data and reproducibility in policy analysis does not yet exist.

With automated evaluation methods, ever-growing data sets can be evaluated in real time and made accessible through decision-maker cockpits. Decision-maker cockpits compile relevant information for rational decision-making in a readily accessible format (dashboard). This can be a combination of personal, publicly available and commercially acquired information. The aim is to make complex decisions promptly and flexibly based on a wide range of information and to assess the impact of different decision options. In the case of real-time policy-making based on the analysis of massive data sets, this form of legitimising policy could potentially turn out to be illusory evidence. Other factors that undermine trust are discussed in the debate about the technically feasible surveillance of citizens during the combined

65 This is possible both retrospectively and prospectively. For example, using search engine queries and data-driven forecasting models (Newcomb et al. 2022) digital earth technologists can detect environmental disasters and estimate the spread of pathogens faster.

evaluation of different data sets and the risk of polarisation of power in data collection and evaluation. Transparent reporting, open policy data and the sharing of algorithms and codes could prove to be success factors in building trust in evidence-informed environmental policy styles.

It is essential to distinguish microforecasting from foresight (Steinmüller et al. 2022). The former refers to issues that are clearly defined and are forecast using quantitative variables for shorter-term horizons. Foresight, on the other hand, focuses on controversial long-term developments. Artificial intelligence in its current form is particularly suited to this type of micro-prediction (predictive analytics). AI can support human interaction in foresight processes (e.g. through chatbots), perform research tasks (e.g. bots that search for news), and help visualise information and the effects of changes (e.g. worst-case scenarios). It is currently uncertain whether and to what extent AI can stimulate foresight. However, an electronic "Pythia" that independently makes forward-looking statements and recommendations based on big data and deep learning does not seem to be on the horizon (Zweck und Braun 2021).

Digital literacy
Combining data from different fields of knowledge is an interdisciplinary and transdisciplinary endeavour that must take into account the complexity of real-world systems. Researchers must acquire skills in algorithmic evaluation, interpretation and quality assurance to deal with the hybrid nature of data sets and their contexts of origin.

Users of algorithmic-based evaluations of hybrid data sets also need to acquire skills in interpreting the meaning for decision-making support. The hybridisation of data sets can open up new areas of research and policy.

Typical citizens and researchers will also have increased access to environmental data and models. For this reason, governments are likely to need to combine, bundle, programme and implement the many data literacy requirements (Interview 3).

Potential implications for environmental research and governance

The possibilities of digital evidence are a classic tech push, often with powerful digital platform companies in the background, which can become a threat to deliberative democracy. In the relationship between science, politics and the public, it must be made clear that scientific data and its interpretation should not have direct consequences for action but is only one of many aspects within political negotiation processes.

Nevertheless, digital developments and power structures need to be addressed politically. Digitalisation, with its data, algorithms and tools, is often driven invisibly by the commercial interests of large, powerful corporations. A policy style based on digital evidence relies on the digital tools and infrastructures of companies such as Microsoft and Alphabet and thus, on the algorithms and data governance provisions embedded in them.

The emerging issues related to digital evidence may indicate a need for action at different environmental research and governance levels;

- Mission-oriented **digital research infrastructures** already exist in the EU. Long-term research infrastructures are also an option for green and digital transitions to reduce overall costs and increase society's problem-solving capacity. Such research infrastructures can accelerate the Twin Transition and contribute to developing evidence-informed policies. From the environment department's perspective, the question is how to take advantage of existing EU capabilities and clarify the need for long-term digital research infrastructures in Germany.

- The environment department should increasingly address **epistemic issues** arising from data-driven research paradigms and, in future, from quantum computing. In this respect, it is important to consider the implications of data-driven research on how research policy is developed and implemented. Finally, data-driven environmental research (data intensity, diversity of datasets, re-use and re-definition of data, etc.) is also creating a new type of evidence that needs to be taken into account by the environment department when making policy decisions.

- Environmental research is in the process of recognising and exploiting the potential of digitally generated knowledge. However, a careful assessment of the importance and scope of digitally generated knowledge is needed. Environmental research has a role to play in providing insights into social interactions and environmental impacts, and this increasingly also requires the **promotion of critical digital literacy**. The emergence of a digital mainstream and its implications for how environmental problems are viewed and addressed need to be critically examined. All other relevant forms of environmental knowledge must also be valued equally, and the diversity of knowledge forms must be preserved over time.

- The potential of **publicly held data sets** should be exploited for environmental research. The first step is to identify areas of environmental governance where big and hybrid data sets support the efficiency, effectiveness and quality of decisions. There are new opportunities here to build and exploit so-called “data assets” by combining anonymised data from different scientific fields, harmonising it and making it usable for different services. In the future, data trust models could play a role in this. Data trustees are neutral intermediaries “who enable a fair balance between the interests of the stakeholders involved and a trustworthy exchange of data, including the necessary access”.[66]

- Exploring alternative and complementary approaches to **agenda setting for environmental policy**, such as data-driven agenda setting, digital participatory agenda setting with stakeholder input (cf. e.g. social-ecological research), and for departmental research agenda negotiation processes, would be important.

- Digitally generated knowledge can support research agenda preparation in **research management**. Transparency, traceability and credibility of sources and processes are prerequisites. This could make the identification of research gaps and new research topics easier. In addition, digitally generated knowledge can supplement and support evaluation of the impact of research projects and programmes. The applicability of existing evaluation criteria for research projects must be examined.

- A prerequisite for developing and implementing a policy style based on digital evidence is an appropriate technological infrastructure and acquisition of the skills and competencies required to use the digital tools for decision-making support. For environmental governance, it is essential to identify places where **“decision-maker cockpits”** already support decision-making based on real-time evaluations (e.g. middle management in environmental authorities) in a useful way or could do so in the future.

- Develop an **environmental data literacy strategy** for various stakeholders within the environment department, in research and for the general public. This strategy should include concrete measures to train the experts involved in the environment department.

- For the environment department, the question is which activities can AI support and how (e.g. strategic foresight). Rarely are decision-makers trained in foresight and decision-making, despite the fact that decision-making support and foresight systems are constantly improving thanks to AI, big data analytics, simulations, collective intelligence systems, participatory e-governance systems, and a greater understanding of the psychological factors that influence decisions. The challenges and solutions are predominantly global in nature, but the foresight and decision-making systems are rarely global in scope because global governance systems cannot keep pace with global interdependence.

- Given the dynamics of development and sudden breakthroughs in the performance of digital applications, **continuous and early recognition of the potential of new digital tools** for environmental research and governance should be considered.

66 Data trust models: German Federal Ministry of Education and Research (BMBF) Funding newsletter dated 23/01/2023

3

Synthesis and outlook

3 Synthesis and outlook

The progress narrative of the digital society is increasingly being intertwined with the recognition that we are living in the Anthropocene. As a result, the environmental impacts of the digital society, and the impacts of the digital society on the environment, are moving to the forefront of environmental research and governance – and at the same time, digital technologies are changing their scope for action.

In this context, the horizon scanning identified and elaborated on ten future topics for the environment department, which are summarised below:

1. What does digitalisation as a driving force of late modernity mean for environmental research and governance, and where are its limits?
2. What new opportunities for action do digital earth technologies present for Anthropocene environmental research and governance?
3. How is digital penetration of the living environment changing the relationship between autonomy and control?
4. How is life changing on the next-generation internet, especially as a result of the metaverse, and what are the implications for environmental research and governance?
5. How can digital statecraft help revitalise democracy and catalyse a socio-ecological transition?
6. Does the increasing digitalisation of government administration also herald a new era of (partially) automated government administration?
7. Which legal regulatory technologies can facilitate more effective implementation of environmental and consumer protection laws?
8. Which applications of digital commons are beneficial for environmental research and governance?
9. What significance and potential does digital money have for environmental research and governance?
10. How do the availability and processing of data, algorithms and digital tools affect research and policy style?

It is an inherent feature of digitalisation that it links previously unconnected social sub-areas physically, informally and also structurally, supporting interrelationships and new emerging structures. The ten future topics are partly driven by the same drivers of digitalisation, such as key technologies or the market dominance of platform companies. Just as digitalisation is reconfiguring society, environmental research and governance must also be adapted for the digital age. This second part of the scan report presents the overarching emerging issues of environmental research and governance in the digital age, which offer some initial guidance for a potential realignment.

First, there is a (1) synthesis in the form of a synopsis of common shared overarching emerging issues, followed by (2) an outlook for environmental research and governance in the digital age using the three horizons approach. Finally, (3) outlines future tasks for the environment department.

3.1 Overarching emerging issues for environmental research and governance in the digital age

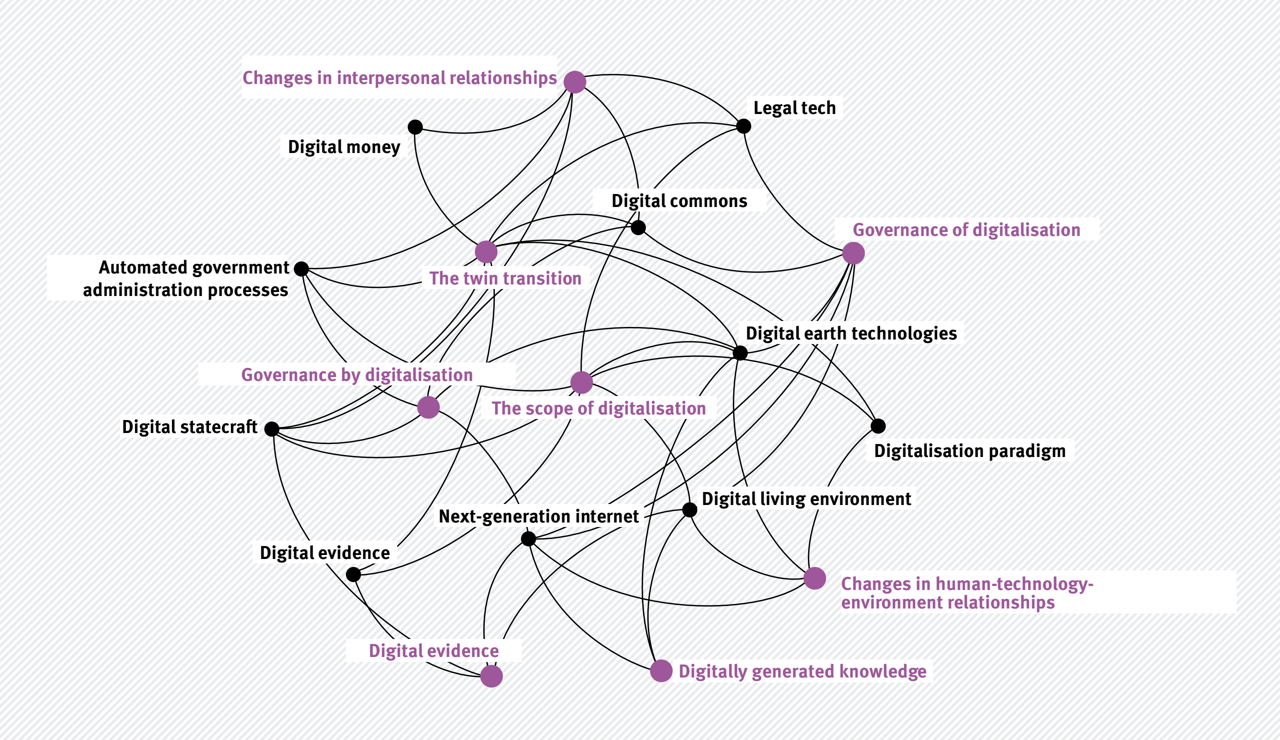
The analysis of the future topics and their drivers reveals several challenges that environmental research and governance will increasingly have to address in the future through the research policy cycle (cf. Figure 02), the so-called overarching emerging issues. The environment department could elaborate on these challenges further in a subsequent process. This section presents the initial starting points.

Digitally generated knowledge

Digital interfaces are generating increasing volumes of environmental knowledge, changing the knowledge base for environmental research and governance. The primary sources will be digital earth technologies and the digital living environment, mediated via the next-generation internet. Data-driven, AI-based hypotheses, difficult-to-reproduce data processing, and information presentation techniques increasingly influence environmental perception and knowledge generation in research and governance.

Figure 05

Future topics and overarching emerging issues



Notes: purple = emerging issue, black = future topic.

Source: Fraunhofer ISI

Therefore, critical reflection and the incorporation of digitally generated knowledge into the current corpus of knowledge is a crucial task. The discussion surrounding the quality of statements generated by ChatGPT is a current example.

The next-generation internet might seamlessly connect existing virtual spaces and incorporate data about physical spaces and artefacts as augmented reality. Digital tools transform data into model-like structures and meaningful content that can inspire people to interact with each other and with machines.

Digital earth technologies span the entire planet and permeate Earth's diverse ecosystems. Interfaces with the biological and cognitive processes of humans, animals and plants enable data exchange. The combination of knowledge from deep penetration and broad coverage of the Earth through digital technologies potentially paves the way for a digital twin of the Earth that can be used to assess the effects of changes and targeted interventions.

The penetration of digital technologies into the living environment is revealing previously unimaginable insights into specific everyday practices. The digital penetration of the living environment is changing people's relationships with technology beyond mere data generation. As a result of the merging of people with digital technology, relationships range from purposeful and parasocial to distanceless.

The digitalisation of environmental perception thus gives rise to three dimensions: knowledge, relationships and action. Digitally generated and processed data can serve as digital evidence to legitimise actions. Increasingly, information about digital commons and stakeholders' needs, actions and positions is generated with the help of digital tools, laying the groundwork for legitimising an evidence-based policy style. Consequently, making normativity visible in decision-making processes and actions becomes a crucial design task.

Digital literacy

The digital living environment and next-generation internet are changing the user competence requirements for digital technologies in everyday life. In the future, digital literacy will also mean being able to recognise the constant offers of assistance from digital technologies, maintaining a healthy distance from digital technologies, and safeguarding analogue life from the digital. Digital literacy acquisition is hampered by cognitive limitations and limited resources, especially when digital systems become autonomous.

Initial experiences with ChatGPT suggest that digitalisation at work requires the development of data literacy, digital communication skills, technical expertise and the targeted use of digital tools for professional purposes and self-reflection and self-stimulation. In particular, digital statecraft, the (partial) automation of government administration processes, and legal tech require employees with a broad range of skills in the careful use of digital technology.

In addition to the skills required for effective use, digital literacy is also needed for digital participation in public life and activities that serve the public interest. It is more a case of developing a literacy that enables recognition and reflection of the underlying reasoning and interests behind the technologies. This includes critical reflection on the classification of digitally generated knowledge.

Changes in human-technology-environment relationships

In the Anthropocene, the digitalisation paradigm as a driver of late-modern society is changing our relationships with other humans and the environment. Our relationship with the environment is becoming more mediated and thus more “artificial”.

Digital earth technologies enable an external view of the Earth, fostering the idea that the Earth’s conditions and processes are fundamentally measurable and malleable. When data from digital earth technologies is linked to the cognitive systems of living beings via interfaces, a new direct (non-mediated) experience window opens simultaneously. This raises new anthropological and philosophical questions about the human-environment relationship.

The potential for alleviating burdens in everyday life through digital assistance is always accompanied by the risk of relinquishing control and autonomy, up to and including the transfer of decision-making power to systems or organisations.

In an extreme scenario, the digitally mediated perception of the world and the intertwining of digital and biophysical systems could reach a point where no non-digital spaces are left, including the absence of wilderness. Consequently, the analogue world would no longer be available as an alternative realm of experience.

Changes in interpersonal relationships

Changes in human-technology-environment relationships also have an impact on interpersonal relationships, especially when digital technologies empower people or machines and robots take on increasingly human-like characteristics.

We tend to anthropomorphise digital companions. In other words, we treat them as if they were human. Our communication counterparts may be digitally enhanced (with or without our knowledge), creating a perceived or unsettling asymmetry in communicative and cognitive capabilities.

Immersion in virtual environments allows us to communicate with simulations of people, such as avatars. In the medium term, the intuitive nature of these interactions in the virtual world and the absence of reward systems in interpersonal relationships may lead us to prefer virtual interactions to physical ones. If we form parasocial relationships with robots, this may hinder our efforts to form interpersonal relationships. This would have significant implications for the environment department staff and the members of society for whom environmental policy is formulated.

As the world of work, including research collaboration and policy work, moves into the metaverse, our relationships with colleagues and external partners are also evolving. The metaverse may contain mechanisms and protocols that foster trust between virtually interacting parties.

Depending on how they are designed, digital commons and digital money have the potential to change our perception of ownership and the providers or owners behind them. New types of incentive systems can generate new types of economic and social interactions, which in turn affect the relationships between the parties involved.

Cybernetic citizenship as a component of digital statecraft, the (partial) automation of government administration processes, and legal tech are transforming the relationship between citizens and the government and its institutions. Beyond the use of specific improved services and the risks that can accompany digitalisation, a new technical regime is emerging that citizens will perceive differently.

Governance of digitalisation
Digitalisation in the environment department and other government institutions requires appropriate forms of governance for the digitalisation process. A basic distinction can be made between the strategies of laissez-faire, the precautionary principle and stewardship in the governance of digitalisation. Furthermore, the dynamics of digitalisation require flexible and adaptive governance (Linkov et al. 2018).

The introduction and application of digital technologies in the environment department involve establishing or expanding the digital infrastructure (including hardware and software) together with all the familiar challenges (interoperability, redundancy, cybersecurity, diversification, flexibility etc.). In the future, it will be necessary to regulate more controversial applications, such as biometric monitoring systems and the opening up of environmental research and governance in terms of data and knowledge. The precautionary principle should remain the guiding principle for the design here. The feasibility of implementing the precautionary principle in the emerging challenges of digital environmental research and governance should be thoroughly analysed at an early stage, e.g. in terms of data protection requirements. IT departments would need to have their remit and technical resources expanded to accommodate the need to find solutions for the compliant use of IT functionalities. One possible solution is stewardship for digital commons (cf. Section 2.7).

The special feature of digital technology governance is that many digital applications, such as those in big data and AI, are developed, marketed and controlled by large multinational corporations. Individual countries or even sub-national governmental units are typically unable to enforce rules in the governance of digitalisation, so supranational organisations such as the EU and standardisation bodies step in. Environment departments have limited influence over the governance of digitalisation, in the case of the metaverse, for example. However, in the case of digital applications that directly affect their fundamental mission (e.g. environmental data governance with commons components), greater scope for action must be identified and, if necessary, fought for.

The governance of digitalisation is subject to particularly stringent requirements when using legal tech to enforce environmental law. In addition to cost-effectiveness, the legal certainty of legal tech, for example, digital monitoring systems, requires special consideration. Possible unintended side effects of legal tech, such as discrimination, must also be considered.

Governance by digitalisation
Digital technology is increasingly being used as a regulatory practice, particularly to address the complexity of living conditions in modern societies. Knowledge-generating and behaviour-guiding actions are already present or encoded in digital earth technologies, the digitalised living environment and the metaverse. The interests of all stakeholders, including technology developers, providers, users and third parties, should be considered. Applying the precautionary principle requires early identification and mitigation of unintended side effects.

On the other hand, there is a discourse on post-democracy and the need to revitalise democracy. Digital environmental governance should be in line with the revitalisation of democracy. Digital environmental governance must meet the challenge of enabling fact-based and ethically defensible opinion and will formation and ensuring public engagement and participation.

Therefore, state governance by digitalisation means aligning the inherent knowledge-generating and behaviour-guiding actions in a way that primarily serves the state's overarching goals. Citizen involvement in digital statecraft must be based on different principles than those of commercial social media platforms. The relationship between citizens and government administration is changing as a result of (partial) automation. The (partial) automation of government administration, with its unique requirements for the relationship between citizens and government administration, differs in some respects from automated management in businesses. Legal tech for enforcing environmental law must be exceptionally well aligned with the relevant objectives of environmental law, taking into account general legal principles such as proportionality. The environment department needs to clarify the role digital technology companies could and should play in basic provisions (e.g. access to near-natural habitats) and public services (e.g. water supply).

Earth system governance through digital earth technologies raises many concerns about funding, access, legitimacy and other aspects. Even though this mode of governance by digitalisation is viewed critically, it can be fuelled by the military-driven proliferation of digital earth technologies. In this scenario, the focus is not primarily on controlling the social metabolism or deliberately using it as a means of warfare or to improve security. Therefore, controlling digital earth technologies for exclusive use in sustainability transitions or dual use is essential.

The Twin transition

The ten digitalisation future topics represent important factors influencing social transitions. They will shape how we will live in the future (digitalisation of the living environment, the metaverse), do business (digital commons, digital money), conduct research (digital earth technologies, digital evidence) and behave in public (digital statecraft, (partially) automated government administration, legal tech). In addition, the future topics show how closely the digital transition and the sustainability transition are intertwined and how one cannot be implemented without the other. Therefore, more of a twin transition with scope for a simultaneous digital and sustainable transition solution is entailed.

It seems particularly important that the digital future topics – beyond all the legitimate requirements for design, discussion of risks and avoidance of hazards – are conceived and designed to enable the sustainable transition. Examples include earth system governance using digital earth technologies, using digital commons and digital money to test alternative economies, and using legal tech to reconfigure law for sustainability transitions.

Digitalisation can also be interpreted as an obstacle to transition in certain areas or by its very nature. Such a narrative opposing the twin transition would need to be based on a solid scientific and participatory foundation. However, if the twin transition narrative continues to fail, it may become necessary to recalibrate and focus society's attention more effectively on transition.

The scope of digitalisation

Digitalisation is emerging as both a megatrend and a paradigm for environmental research and governance. In terms of its spread and design, two areas of application can be distinguished: the material penetration of the world and state governance.

The digitalisation of the world (especially digital earth technologies, penetration of the living environment and the metaverse) and its direct, indirect and systemic effects need examining more closely from an environmental perspective. On this basis, it is possible to formulate design briefs for environmental research and governance, which may include environmental scope restrictions. Examples include the recyclability of materials and, from an environmental perspective, the negative indirect effects of digitalisation on the environment, such as the acceleration of consumption in the metaverse.

Citizens often set exceptionally high standards for government action. Particularly in the construction of digital generated evidence, attention must be paid to the extent to which participation is effectively enabled and normativity is made explicit. If governance of digitalisation cannot adequately address these standards, this will limit the scope of digitalisation.

In a democratic society, determining the scope of digitalisation requires the participation of all groups with legitimate interests and ethical expertise and review procedures, such as those provided by the German Ethics Council. In doing so, it is important to ensure the perspective of social environmental ethics and draw attention to the linguistic and actual material marginalisation of environmental aspects.

3.2 Environmental research and governance in the digital age using the three horizons model

The three horizons model (Curry and Hudson, 2008) queries the compatibility of the three horizons with the current state of the world over time. In terms of environmental research and governance in the digital age, the three horizons can be interpreted as follows:

- Horizon 1 describes environmental research and governance that is not digitalised or has only been digitalised to a limited extent (e.g. intranet and the UFORDAT environmental research database). Their compatibility with the current state of the world continues to decline over time.

- Horizon 3 describes the emerging issues resulting from the evolution of the future topics. These are issues and topics that are increasingly compatible with the current state of the world (e.g. the increasing sophistication of digital tools and the rise of digital literacy in society).

- Horizon 2 describes potential transformations of environmental research and governance that could be compatible with the current state of the world in the medium term (e.g. twin transition in environmental administration, legal tech to create a legal framework that enables transitions).

In the three-horizon model, digital developments are shown separately for environmental research and governance, which evolve over time and have a different compatibility with the current state of the world. The collision zone, in other words, the period during which the horizon items change in terms of their compatibility, can be estimated from today's perspective to be between approximately five and fifteen years.

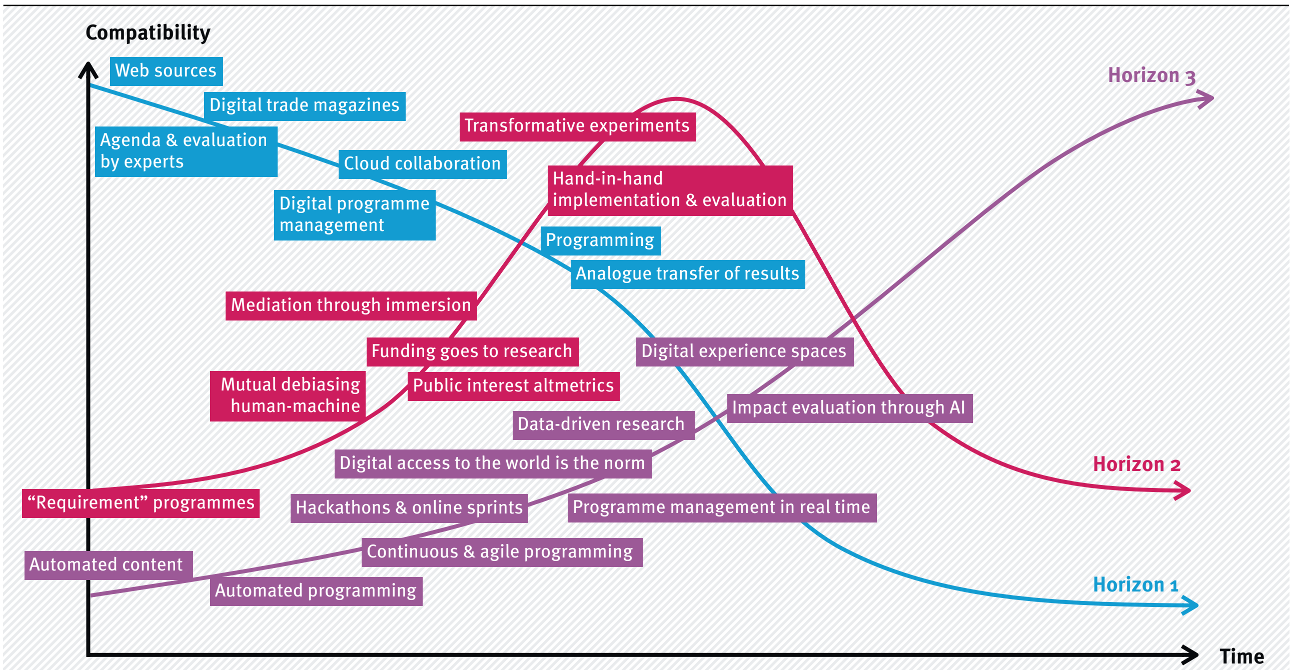
The following statements are not to be understood as forecasts. Instead, they describe plausible assumptions, how environmental research and governance could develop within the three-horizon model.

Research, especially environmental research, is currently one of the most digitalised areas of society (**Horizon 1**):

- Research projects are initiated by summarising the existing state of research from current sourc-

Figure 06

Environmental research in the digital age – schematically represented in the three-horizon model



Notes: various digital developments affecting environmental research are plotted on the three horizons based on their compatibility with the current state of the world; blue: horizon 1 – current established practices, purple: horizon 3 – emerging practices, red: horizon 2 – transformative practices.

Source: Fraunhofer ISI

es, often only available in digital format (including the Web of Science and research databases), and converting it into research ideas and specific research projects, increasingly with the help of digital collaboration tools. Environmental research, in particular, is often very data-intensive and requires support from algorithm-based analyses and processing, usually performed by programmers. The use of cloud services for simultaneous editing of research documents and communication between project participants has become commonplace. Environmental research projects are increasingly created as transformative research projects, enabling the involvement of different societal stakeholder groups, often with the help of digital collaboration tools. Communication about environmental research projects is increasingly multimedia-based, especially digital. Most research projects are published in digital journals, which also publish the background information for the technical articles and raw data sets. Transferring the results of research projects into practice usually requires collaborations that only have a significant digital component in the case of digital innovations.

- Most research programmes are generated through administrative processes within research funding institutions, relying on the expertise of internal and external experts and their assessments of research needs. The digital involvement of stakeholders in the design of research programmes is the exception in environmental research. The social-ecological research agenda-setting process is one of these exceptions. Funding bodies or project management agencies manage research projects using digital tools. Project management for research institutions is also increasingly supported by software and databases. Today, most research projects and programmes are evaluated manually based on predefined categories, or independent evaluation projects (ex-post, concurrent) are set up.

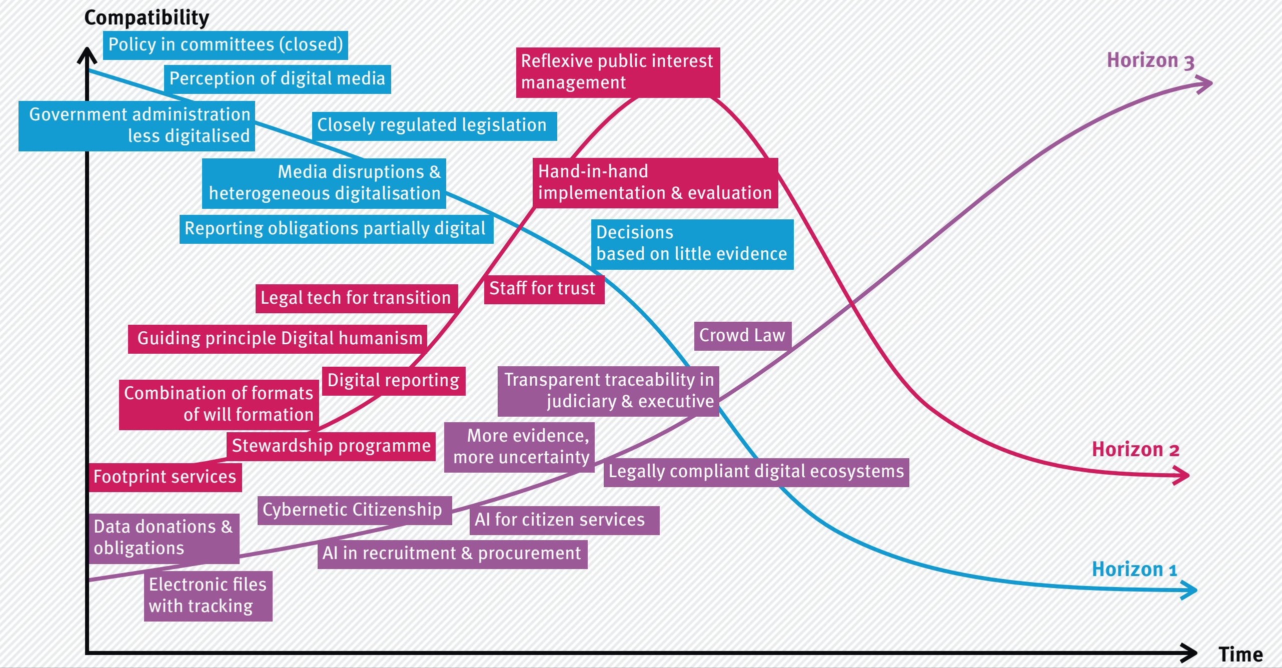
In the future, as the world becomes increasingly digitalised, the current practices of initiating, implementing and exploiting research projects, and programming, administering and evaluating research programmes will by and large become less compatible. Digital environmental research practices are emerging on the horizon that address the digital penetration of the world at the level of both research projects and research funding programmes (**Horizon 3**):

- The first research projects on automated indexing of internet content are being initiated. These include data mining and text mining from scientific sources and using knowledge systems and chatbots (including language models such as ChatGPT). Research project hypotheses are increasingly data-driven rather than theory-driven, with the promise of exploitation of the expected research results being justified by the data basis. Formats such as mass digital hackathons and online research sprints use the latest digital collaboration tools to involve larger groups of stakeholders and achieve results faster, even in real time in some cases. Digital earth technologies, the next-generation internet and the digital penetration of the living environment are creating new digitally mediated entry points for environmental and transformative research. In the face of unresolved major challenges, taking advantage of these new opportunities seems prudent. Reflecting on the epistemic quality of digital research logics must emerge as a design task. Research projects are increasingly being used through digital experience spaces and multimedia storytelling that employ fun and artistic digital presentation modes, in addition to specialised publications and innovative market launches.

- There are methods for using automated procedures to identify and formulate the state of research and demand for research on the financial side as well. This can also highlight relevant stakeholder groups that should be involved in the more specific design of requests for proposals. The formats currently known as stakeholder consultations could give way to much more agile and continuous formats that explore the digital world in an automated way and respond to needs. AI-supported future research programme management will be able to identify the gap between research funding aspirations and reality almost in real time, using decision-maker cockpits to identify opportunities and risks throughout the research funding process to support corrective decision-making accordingly. Future evaluation of research programmes may rely more heavily on

Figure 07

Environmental governance in the digital age – schematically represented in the three-horizon model



Notes: various digital developments affecting environmental governance are plotted on the three horizons based on their compatibility with the current state of the world; blue: horizon 1 – current established practices, purple: horizon 3 – emerging practices, red: horizon 2 – transformative practices.

Source: Fraunhofer ISI

AI-based analysis of the digitally generated public impact of the research projects included in the programme.

The compatibility of emerging digital research practices with the world is initially low (horizon 3) and does not rise above the declining compatibility of established research practices (horizon 1) until the medium term.

Environmental research recognises the digital changes in research and its societal context and adopts its position accordingly (**Horizon 2**):

- Research projects are initiated by using AI to identify and reflect the biases of humans in research. Humans, in turn, identify and reflect the biases of AI. This reflexive and dialogical process of acquiring knowledge also shapes the conduct of future research projects in the Anthropocene, where a world permeated by digital technologies and shaped by human-altered metabolisms impacts back on humans. Implementing such research projects requires codes of conduct specifying rules for handling digital data, algorithms and tools. Research projects are embedded in the world in an experimental and transformative way through the digital interface. Through this embedding and the digital networking of the world, research projects can become broadly effective in the short term. The publication of digital data, algorithms and tools in the public interest in the Anthropocene should be designed in a way that makes it a key factor for successful scientific work. The broader mediation of transitions can rely on the expansion of the infrastructure for immersive worlds and requires appropriate shaping through environmental and sustainability education.
- Research funders will align research funding more closely with the needs for real-world change and the guiding principle of digital humanism. This applies to both basic and application-specific research on digital logics in the Anthropocene. Funding programmes could continue to serve this purpose. However, research funding could also be flexible and allocated to areas with evident links between real-world change requirements and research capabilities (e.g. open research platforms). The integration of research into the real

world is one of several prerequisites for capturing the real-time impact of research. Implementation and evaluation of environmental research funding thus go hand in hand in the digitally permeated Anthropocene.

Environmental research continues its tried-and-tested activities while at the same time taking early note of emerging developments. Thus, while in the short term, it may be less compatible with the current state of the world than existing environmental research, in the medium term (horizon 2), it is the most compatible of all possible environmental research scenarios, as the reflexive adoption of emerging digital environmental research practices becomes more effective.

In the collision zone of the three horizons for environmental research in the digital age, issues related to digitally generated knowledge, digital literacy, changing human-technology-environment relationships, changing relationships between humans/stakeholders, governance of and governance by digitalisation, the twin transition and the scope of digitalisation will intensify (cf. Section 3.1, Emerging issues).

Governance, including environmental governance, is currently one of the comparatively less digitalised areas of modern society (**Horizon 1**).

- The policy design, including environmental policy and its legal codification, is based on established processes with their defined bodies, hearings and legislative initiatives, committee and cabinet meetings, and closed sessions with stakeholders from business and, to a lesser extent, civil society and research. While the increasingly digitally mediated opinion formation is recognised, independent digitally mediated will formation is not currently an integral part of environmental policy formation processes. Legislative processes are designed to be open to normative negotiation by legitimate political stakeholders and their various objectives within constitutional limits. Decisions based on partial evidence of perceived impacts but with significant uncertainty are the norm. Digital tools to support collaboration between departments and stakeholders currently only play a limited role.

- Government administrations, including environmental administrations, have only been digitalised to a limited extent. Paper files, databases, email exchanges, and numerous media breaks are typical of the prevailing administrative practices within most environmental authorities. Most environmental authorities are based at the municipal level and have widely varying levels of digital equipment and services. The expansion of digital citizen services through a centralised portal is being monitored.[67] Environmental law is primarily enforced through reporting obligations, such as those imposed on businesses that can only partially use digital input formats.

As the world becomes increasingly digitalised, the compatibility of current policy design practices, policy processes and law codification, and the design of digital government applications, government administration processes and environmental law enforcement will decrease.

Digital environmental governance practices are emerging on the horizon that address the digital penetration of the world at the policy and government administration levels (**Horizon 3**):

- In the context of cybernetic citizenship, policymakers may be able to rely more on citizens' self-perception in the future. These citizens not only provide data as donations for public-interest-oriented projects (either voluntarily or as required by applicable laws), they also actively articulate policy needs and participate in legislative processes through CrowdLaw. Digital tools support the transparency of who has influenced legislative processes and executive decisions, in what direction and to what extent. This provides an opportunity to give greater weight to civil society stakeholders and research without necessarily ensuring better policy outcomes in terms of environmental protection. Digitally generated evidence on environmental issues may become more important but, at the same time, in the Anthropocene, the certainty of policy impacts

67 The German government is not that digital yet – INSM

decreases due to stronger interconnection of subsystems. Digital technology allows for more effective design, a broader reach of will-forming processes and greater transparency in policy design processes.

- In the future, government administration may rely on permanently active electronic records that can be processed without media disruption and are traceable. As in the private sector, the recruitment of government administration staff and procurement will use artificial intelligence to access the best talent, products and services for their respective purposes. Authority departments and authorities communicate with each other within digital ecosystems rather than in hierarchically organised, separate entities. In these digital ecosystems, legal certainty about the authority of individuals, departments and ministries is digitally stored and encoded. In external relations with citizens and businesses, partially automated services dominate, e.g. for answering enquiries and fulfilling reporting obligations. The prerequisite for this is the comprehensive digitalisation of the government administration. The planning, processing and verification of monetary transactions are performed using digital money.

The compatibility of emerging digital governance practices with the world is initially by and large low (horizon 3), but in the medium term, rises above the declining compatibility of established governance practices (horizon 1).

Environmental governance recognises the digital changes in governance and its societal context and adopts its position accordingly (**Horizon 2**):

- Digital governance follows the guiding principle of digital humanism. Policy projects are initiated and developed using digital tools to combine different will-forming formats, make the influence of different stakeholders visible and intervene and counter accordingly within the policy process if affected stakeholder groups and/or public interest are neglected. Digital technology promotes the coexistence of social groups, not in the sense of “mechanically resolving” conflicts of interest, but by helping to give voice and argumentative weight to legitimate interests, particularly in relation to public interest, including environmental protection. In the medium term, a legal framework enabling transformations will be created based on assessments of conflict situations that legal tech algorithms have digitally saved.

- Government administrations make data and algorithms available to citizens, NGOs and businesses in a differentiated way for private, private sector and public interest purposes. Citizens can digitally map their environmental footprint, benchmark it and receive personalised recommendations on reducing it measurably. The enforcement of reporting obligations under environmental law is largely digitalised and verified by systematic human review. On the other hand, the government administration is aware of the human factor within its relationship with citizens and largely delegates government administration processes that require a higher level of trust (such as advice in certain life situations and regarding sustainability) to its employees.

Environmental governance continues its tried-and-tested activities, while at the same time taking early note of emerging developments. Thus, while in the short term, it is less compatible with the current state of the world than existing environmental governance, in the medium term (H2), as the reflexive adoption of emerging digital environmental governance practices becomes more effective, it is the most compatible of all possible environmental governance scenarios.

In the collision zone of the three horizons for environmental governance in the digital age, issues related to digitally generated knowledge, digital literacy, changing human-technology-environment relationships, changing relationships between humans/stakeholders, governance of and governance by digitalisation, the twin transition and the scope of digitalisation will intensify (cf. Section 3.1, Emerging issues).

3.3 Towards a revised approach to digital issues in environmental research and governance

Environmental research creates the knowledge base for environmental governance. In principle, this knowledge base is incomplete and needs to be extended to include normative aspects. Environmental governance needs to adopt a position in relation to the potential horizons. The progression over time of the horizons may not necessarily follow the pattern described in the three horizons model. The challenge lies in tracking all three horizons in a way that will prepare environmental research and governance for the coming digital age in the short, medium and long term. In addition to new areas of responsibility for environmental research and governance, the most significant challenge is integrating digital dynamics into the environment department's daily operations.

New environmental research areas of responsibility
Environmental research policy can develop a research agenda by supporting the development process through the automated indexing of digital knowledge assets and the wider involvement of stakeholder groups through digital collaboration tools. The complementarity of the mutual debiasing of humans and machines needs to be explored in depth to increase the legitimacy and acceptance of AI-based methods in environmental research as well. This may require codes of conduct that specify rules for the handling of digital data and algorithms.

The digitalisation of the world opens up new methods of observing, studying and influencing real-world everyday behaviour. Conceptually, it is crucial to acknowledge the fundamental changes in human-technology-environment relationships in the digital age and the multifaceted delegation, enhancement and communication needs of people and to shape them with environmental protection in mind. Future research projects will be more embedded in the world due to their digital, experimental and interconnected nature, allowing them to become broadly effective in the short term. It is important here to proactively anticipate the desired and undesired side effects of reframing digital environmental research.

In the future, research funding must better recognise the real-world need for change and, in certain circumstances, actively implement more agile funding methods ("towards the need for change and existing capabilities"). Implementation and evaluation of environmental research funding thus go stronger hand in hand in the digitally permeated Anthropocene.

Particular attention should be paid to exploring a research and regulatory framework that enables sustainability transitions through digitalisation. To this end, it is also necessary to identify and remove any barriers to experimental digital formats embedded in the real world. For example, governance labs can be used to test the effects of different incentive systems on economic and social self-perceptions. Environmental and sustainability education should address the possibilities and limitations of immersive worlds for the mediation of issues.

The scaling of model sustainability transitions must be examined under the conditions of the current balance of power held by digital platform companies. It is also important to critically examine the systematic alignment of digital platform companies towards sustainability transitions.

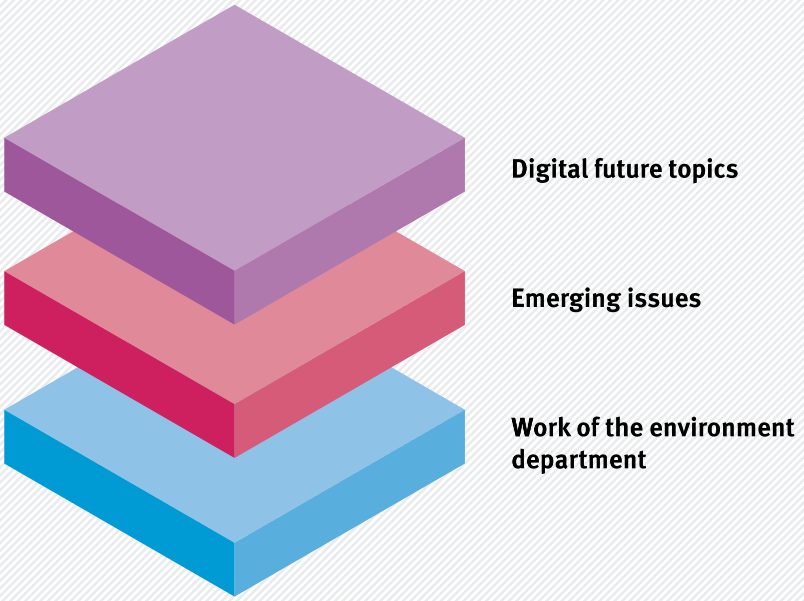
New environmental governance areas of responsibility
First and foremost, environmental governance needs to explore and evaluate the scope and limits of digitalisation for environmental governance and actively incorporate it into policy processes. This includes maintaining human contact, for example, in sustainability communication regarding specific life situations. The nature and extent of the environment department's participation in inter-ministerial policy and practical activities in the context of the twin transition will determine whether the digital transition will be sustainable and whether environmental governance will benefit from digital collaborations. Environmental digital policy should follow the guiding principle of digital humanism and help to shape it.

The environment department has creative freedom with regard to targeted digitally supported opinion and will formation and involvement and participation in the digital public sphere, and can combine these digital formats with established formats. The potential of digital formats lies primarily in making the influence of different stakeholders visible and in identifying neglected stakeholder groups and protected goods in environmental governance processes in order to take appropriate countermeasures.

In the future, environmental administrations could provide data and algorithms to stakeholders in a more systematic way, differentiating between private, private sector and public interest purposes. The environment department can also promote access for citizens (particularly to services for calculating, benchmarking and reducing their environmental footprint) and businesses (particularly to services for the digital

Figure 08

Three approaches to systematically explore environmental research and governance in the digital age



Notes: The three entries can be interpreted as alternative approaches to the contents of this horizon scan.

Source: Fraunhofer ISI

handling of reporting obligations) to environmental administration services. The environment department could play a pioneering role in the stewardship of environmental digital commons (data, algorithms, software, etc.).

Other aspects of governance, such as CrowdLaw, legal tech and the digital state as a new technological regime, lie beyond the core area of expertise of the environment department. The latter could act as a driving force in this respect, subject to qualification of the scope and limits of digitalisation. In the medium term, a legal framework enabling transformations could be created based on assessments of conflict situations that have been digitally saved by legal tech algorithms.

Integrating a digital compass into the work of the environment department

Environmental research and governance in the digital age can be approached through three avenues: the ten digital future topics, the eight overarching emerging issues, and various work areas/activities of the environment department (Figure 08).

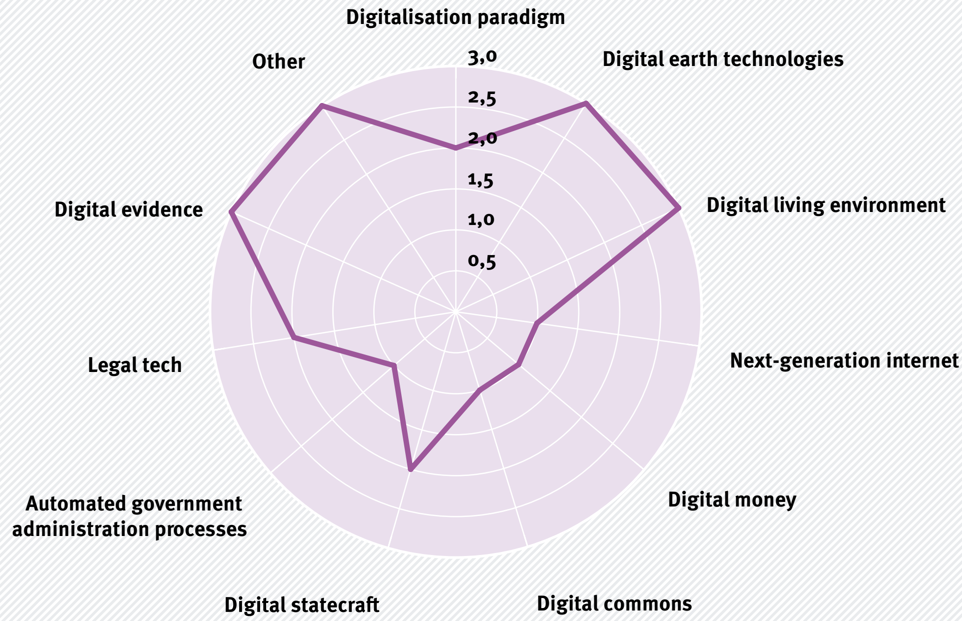
The potential implications of a digital future topic and its emerging issues for environmental research and governance in the digital age are kept comparatively general. In the environment department's practical work, there is a need to narrow the topic down to a specific work area or activity.

For this purpose, the project also developed a tool to quickly generate an assessment of the relevance of future topics and emerging issues for the environment department's specific work areas or activities (Figure 09). The tool can generally be used to frame a new activity (e.g. develop a project plan) or retrospectively reframe an ongoing activity (e.g. searching for and recruiting staff). Essentially, digitalisation is applied systematically as a framework through which existing or planned activities are examined, allowing for a new interpretation.

In producing a digital compass, the importance of a future topic to an environment department activity is qualitatively assessed and then rated on a scale of 1 (marginal importance for the activity), 2 (additive: additional aspect for the activity), 3 (important) and 4 (transformative change in the [perspective] of the

Figure 09

Example showing how the relevance of digital future topics is assessed for a fictitious environment department activity



Notes: Relevance scale increasing from 0 to 3, showing the relevance of the ten future topics identified from this horizon scanning and "others" to demonstrate openness

Source: Fraunhofer ISI

activity). A spider-web diagram of this type can be used for an overarching activity, such as creating a research project, and sub-activities, such as idea generation, performance specifications, and the management and evaluation of bids.

What is considered a digital future topic is fundamentally open to change. With this in mind, the list of ten digital future topics presented here is supplemented by an additional category of "other", which may be populated from ongoing or future horizon-scanning processes.

With its three levels as a didactic starting point, this structured, systemic approach enables a relevant discourse on digitalisation rather than being involved in numerous activities in a limited and heterogeneous way.

Continuation of the horizon scanning

The horizon scanning took place mainly in 2021 and continued with reduced intensity until 2023. Changes such as the Internet of Things, big data, artificial intelligence, the introduction of new generations of mobile phones and increasing computing power are occurring all the time and at the same time. The horizon scan presented in this report is a snapshot. However, digitalisation is a highly dynamic trend, with new applications and technologies constantly emerging. Society is also changing, both as a user of digital tools and because we live in evolving living environments (e.g. the global geopolitical situation and uncertain climate events as both a threat and an opportunity for climate policy).

While the future topics identified are broad and will continue to be relevant for a long time, a new or ongoing horizon-scanning process on environmental research and governance in the digital age could potentially reveal additional interesting topics and formats. Many environmental professionals in the environment department lack time and deeper digital literacy, while digital professionals often lack expertise in environmental research and governance methods. Horizon scanning for the continuous early identification of opportunities and risks of digitalisation for environmental research and governance could, therefore, help to strengthen the environment department's capability as an institution significantly.

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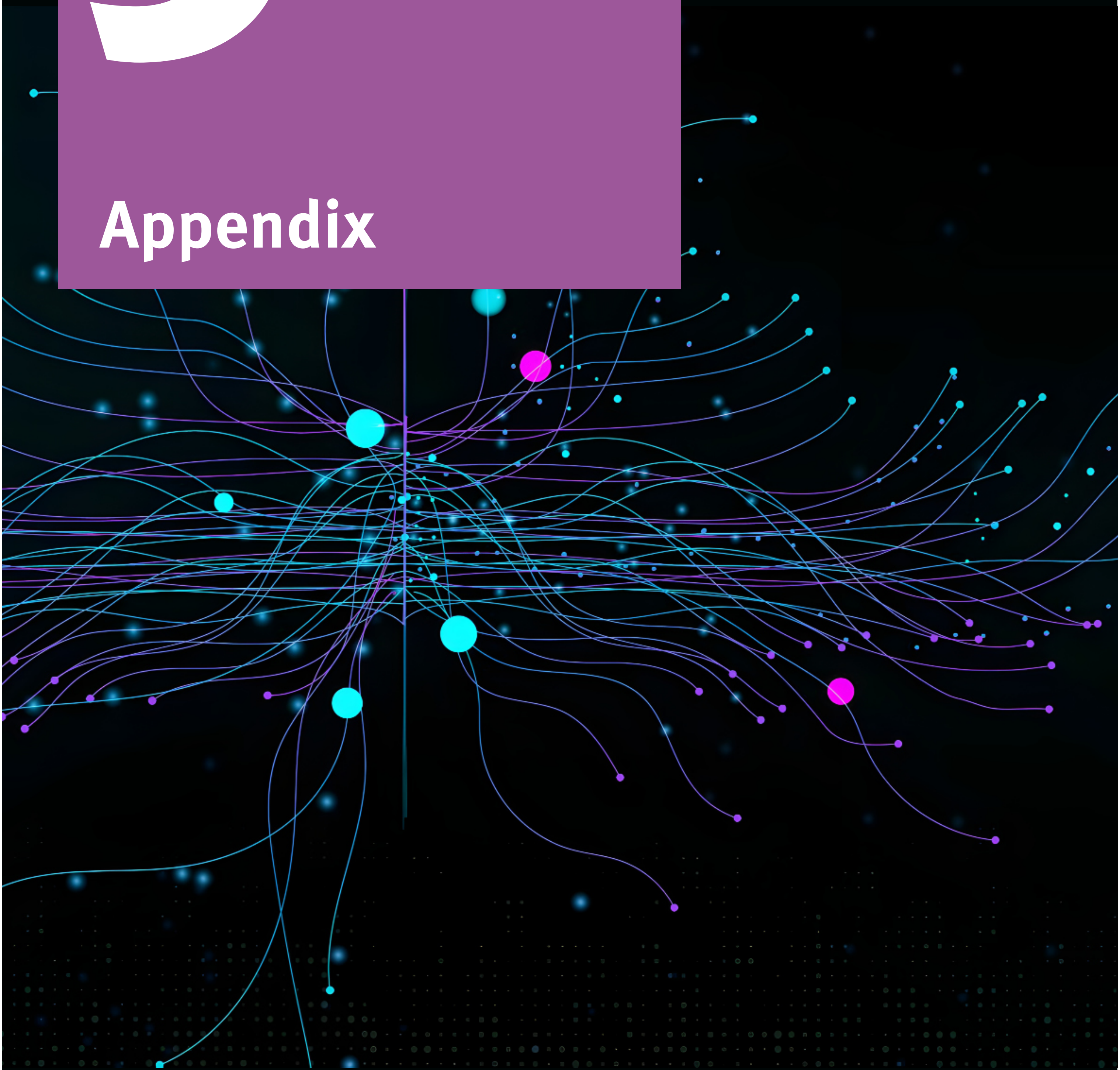
5

Appendix



5 Appendix

A A more detailed description of the horizon-scanning methodology

As part of this project, the "Environmental Research and Governance in the Digital Age" topic was prepared for the environment department's strategic foresight. The requirements included identifying all digital developments that are highly relevant to and new for environmental research and governance (including changes in its own societal context). A topic-specific horizon-scanning process was developed, performed and evaluated to achieve this. The scan report provides a comprehensive, detailed and structured overview of the issues and developments "on the horizon".

The starting point for the horizon-scanning process was a specific approach developed by the Fraunhofer ISI Competence Center Foresight to reduce bias in relation to signals of change and future trends. (Figure A1).

In particular, power, mentality and surveillance filters, and confirmation, overconfidence and overprediction biases, were addressed by assembling a scanning team with diverse professional backgrounds[68], using different media sources to capture signals of change, and conducting accompanying interviews to guide the scan. The power filter arises from power dynamics, and the mentality filter from established thought patterns in the scanning process. The surveillance filter refers to the fundamentally limited resources of any scanning process. Typical biases in the search for and evaluation of signals include confirmation (confirming or supporting previous assumptions and values), overconfidence (overestimating one's own ability to judge) and overprediction (extrapolating from the present to the future).

These preliminary considerations lead to the following **requirements for the topic-specific horizon scanning**:

- equal consideration of technical and social signals of change in the context of digitalisation,
- consideration of mainstream and niche discourses and systematic comparison of the two in signal evaluation,
- broad search in established fields (sectors, disciplines) and also in marginal fields,
- use of partially automated tools (e.g. web scraping) and creative methods (e.g. exploratory interviews with thought leaders and foresight experts) that critically compare and contrast different observations and consider patterns.

As a result, the following scanning strategies were used (Figure A2).

The (partially) automated scanning (Geurts et al. 2021) included the following steps: selection of a web news provider (NEWS-API was chosen)[69], the scraping of web news using an ontology of key terms from the areas of digital technology, digital society, (environmental) research and (environmental) governance in English[70], topic modelling[71] and the identification of highly relevant individual news articles.

In addition, digitally available primary and secondary sources that met the criteria of high quality, timeliness, originality and, as a whole, diversity were evaluated. The following four formats were the main focus:

68 The scanning team includes a historian and data scientist, a Japanologist, Sinologist and business economist, a communications scientist, sociologist and economic policy analyst, a psychologist, a physicist, a political scientist and an environmental engineer.

69 NEWS-API provides continuous web scraping of more than 50,000 news sites and news blogs (from publications and companies) from 54 countries. These countries include the USA, China and Germany, among others. The news is divided into six categories: business, entertainment, sports, health, science and technology. The news goes back one to two years. In addition to headlines, full texts and primary sources, the web scraping provides metadata including hyperlinks. (https://newsapi.org/).

70 The key digitalisation terms are used internationally in English (e.g. Smart X), so they also appear in news articles in other languages. In terms of countries, therefore, not only English-speaking countries such as the USA, England and India are covered, but all 54 countries for certain terms. However, Estonia, one of the most advanced nations in terms of digital governance, is not represented. News from the Estonian government is discussed in the media scraped by NEWS-API though, such as the BBC, the Economist and Wired.

71 The (partially) automated generation of topic maps based on the frequency of terms and the degree to which they are linked.

- Journals: e.g. Science and Public Policy, Environmental Science and Policy

- News websites, blogs and forums: e.g. Global Power Shift, The GovLab

- Conferences: e.g. World Economic Forum, Making Sense of Digital Society

- Archives and meta-sources: e.g. PhilSci Archive, Stack

Complementary interviews were also held with visionaries and foresight practitioners (cf. Appendix C1) to correct any conceptual biases.

A focused search for combinations of terms covering all 20 scan fields widened the coverage and produced additional evidence for individual signal candidates.

The scan team regularly discussed and modified the signal candidates and compiled a set of 69 signals of change in environmental research and governance due to digitalisation.

Sense-making took place in interactive formats, including a clustering workshop and a future workshop.

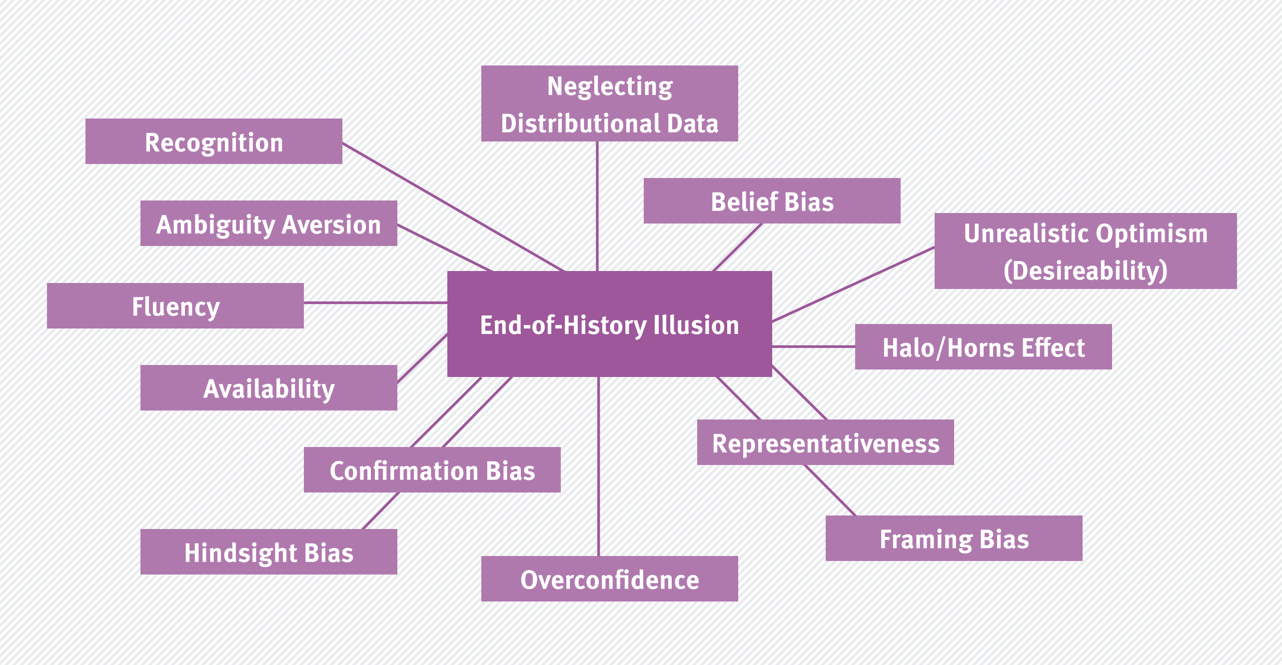
a. The clustering workshop was held on 29 September. Most participants came from the BMUV, the German Environment Agency and the Fraunhofer Competence Centers Foresight, Sustainability and Infrastructure Systems, Emerging Technologies and Policy and Society (cf. Appendix C2). The workshop aimed to sift through the trend signals identified in the horizon scanning, qualitatively assess them, and use them to develop new future topics.

b. The future workshop took place on 13 January 2022. In addition to representatives from the environment department and Fraunhofer ISI, external experts from science, foresight and politics took part (cf. Appendix C3). By involving external experts, the workshop aimed to find emerging issues (new developments, topics or questions) and determine how they relate to environmental research and governance.

Finally, including additional research on term definitions, structuring and foresight studies, the ten future topics were elaborated on, the connections between their emerging issues were analysed, and they were synthesised in an alternative way in the three horizons framework (Curry und Hodgson 2008) for environmental research and governance.

Figure A1

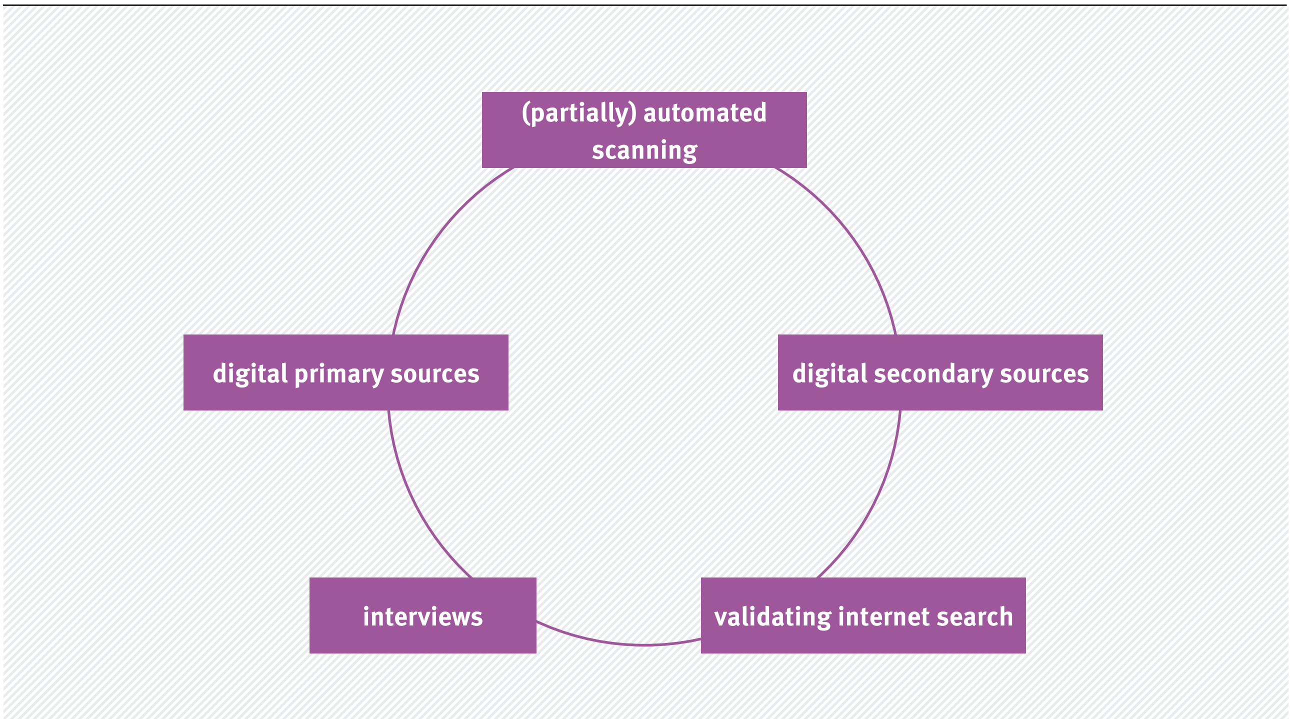
Selection of biases studied by the Competence Center Foresight



Source: Schirrmeister et al. 2019

Figure A2

Access to sources for the horizon scanning in the “Environmental Research and Governance in the Digital Age” project



Source: Fraunhofer ISI

B Additional presentation of emerging trends and topics

The search for signals of change centred on the following questions:

- What are the emerging developments and trends in environmental research and governance due to digitalisation that go beyond known studies that the environment department could use to be well prepared for the future?
- How is digitalisation transforming the environment department's societal context (policy target groups, policy systems, understanding of democracy, opinion formation processes, etc.), and what impact might this have on environmental research and governance in the future?

As a result, 69 signals of change were identified, formulated in approximately 6–10 lines and supported by 2–6 sources (unpublished).

Table B1

Overview of the signals of change

Code	Title
DT1	Quantum computing: a leap in computing power and cybersecurity
DT2	DNA computing and DNA storage: a leap in computing power and storage capacity
DT3	Digital organism: convergence of digital technology and living organisms
DT4	Omnipresent digital measurement technology
DT5	Edge computing: new decentralised data processing capabilities
DT6	Small data: niche or alternative to big data?
DT7	Autonomous vehicles with hybrid missions
DT8	Digital earth technologies: “Smart Earth” and digital twin of the Earth?
DT9	Next-generation internet
DT10	Next-generation mobile networks
DS1	Digital real-time translations: language without borders
DS2	Soundscapes: new digital approaches to everyday life
DS3	Digital companions
DS4	Equal digital communication with animals
DS5	AI-supported decision-making
DS6	“Decision-maker cockpits”
DS7	Life in the metaverse – an all-encompassing digital environment/world?
DS8	Mixed reality is changing work processes
DS9	Avatars as professional representatives: facilitators, intermediaries or contracting partners
DS10	Earning money digitally through play
DS11	Digital euro for transformed payment processes and habits
DS12	Implications of digital currencies
DS13	Digital assetization technologies: “owning a piece of everything” principle
DS14	Study and promotion of opinion formation in the digital world
DS15	Influencability of online users’
DS16	(Environmental) communication with storytelling in the multimedia world
DS17	Digital learning environments
DS18	Industry 4.0 experiments and simulations at the interface with environmental research

Notes: DT – digitale technology, DS – digital society, DF – digital research, DG – digital governance

Code	Title
DS19	Deep tech innovation
DS20	The military as a pioneer for digital environmental exploration?
DS21	Polarisation of power due to a deepening digital divide
DS22	Social scoring in Germany as well?
DS23	The increasing influence of digital technology on people's (circadian) biorhythms
DS24	Changing place attachment and sense of location in the digital age
DF1	"Digital" as today's new buzzword, including in environmental and government research
DF2	Understanding the human-environment relationship and the Anthropocene better with smart research
DF3	Open science ecosystems
DF4	Long-term digital research infrastructures
DF5	National Research Data Infrastructure (NFDI) with centrally aggregated environmental data
DF6	Automated research management
DF7	Automated indexing of internet content
DF8	"Good enough" paradigm – tolerance for imprecision in automated research
DF9	Online research sprints for greater agility in research
DF10	Altmetrics in research for measuring quality and impact
DF11	Computer simulations not completely transparent (epistemic opacity)
DF12	Promise of radical new knowledge through AI
DF13	AI as a driver of digital biasing and debiasing
DF14	Convergence of human and artificial intelligence
DF15	Prediction markets
DG1	State 4.0 – personalised, automated and participatory
DG2	Digital cooperation between authorities
DG3	CrowdLaw
DG4	New digital participation and networking platforms
DG5	Towards a living lab society through crowdsourcing and citizen science
DG6	Cybernetic citizenship – the active participation of citizens in policy and data use
DG7	Data and algorithms as public digital goods
DG8	Data donations
DG9	AI for HR management within the environment department
DG10	AI for public procurement within the environment department
DG11	Digital research and innovation policy (digitalisation of science and innovation policy – DSIP) initiatives as alternatives to deliberative or administrative approaches
DG12	Digitalisation for easier evidence-based policy style
DG13	Evaluation of (environmental) governance using AI
DG14	Normative requirements for the development of future digital applications
DG15	Digital technology sovereignty
DG16	Public services within the platform economy
DG17	Transformation of global governance by digitalisation
DG18	Required process acceleration: digital, sustainable or twin transition?
DG19	Public investments in digitalisation and green innovations during the COVID-19 pandemic
DG20	Intensive data collection – but untapped data-use potential

Notes: DT – digitale technology, DS – digital society, DF – digital research, DG – digital governance

C Parties involved in the scanning process

Table C1

Interviewees to guide the scan

Last name	First name	Institution	Date
Belorgey	Nicolas	CEPS (France), CSH Dehli (India)	27 July 2021
Gheorghiu	Radu	Prospectiva (Romania)	20 July 2021
Meissner	Svetlana	BTU Cottbus (Germany)	21 July 2021
Popper	Rafael	Futures Diamond Ltd. (UK)	04 August 2021
Tonn	Bruce	Three3 (USA) and the Association of Professional Futurists	20 July 2021

Table C2

Clustering workshop participants (29 September 2021)

Last name	First name	Institution	Department/Position
Bilski	Noah	BMUV	Unit Z III 3 Internal Communication, Government Administration Digitalisation
Cuhls	Kerstin	Fraunhofer ISI	Competence Center Foresight
Döscher	Kerstin	UBA	PB 1/Planning And Control, Strategic Controlling, Research Coordination
Dorsch	Marcel	UBA	PB 1/Presidential Department/Digital Change and Sustainability Transformation
Erdmann	Lorenz	Fraunhofer ISI	Competence Center Foresight
Fritsch	Peter	BMUV	G II 3/Regional Planning, Building Law, Rural Development
Gotsch	Matthias	Fraunhofer ISI	Competence Center Sustainability and Infrastructure Systems
Kimpeler	Simone	Fraunhofer ISI	Competence Center Foresight
Koller	Matthias	UBA	I 1.1/Fundamental Issues, Sustainability Strategies and Scenarios, Resource Conservation
Kowalczyk	Katrin	BMUV	G III 3/Sustainability Policy and Citizen Involvement
Löwe	Christian	UBA	Z 2.3 / Digitalisation
Rörden	Jan	Fraunhofer ISI	Competence Center Foresight
Roth	Florian	Fraunhofer ISI	Competence Center Policy and Society
Salzborn	Nadja	UBA	I 1.3/Fundamental Jurisprudential Issues
Schulz	Alexandra	UBA	I 1.5/National and International Environmental Reporting
Schwerz	Anette	BMUV	G I 4/BMUV Research Officer, Environmental Research, Science, UBA Supervisory Control Coordination
Veenhoff	Sylvia	UBA	I 1.1/Fundamental Issues, Sustainability Strategies and Scenarios, Resource Conservation
Dickow	Marcel	UBA	Z 2.3 / Digitalisation and environmental protection, e-government
Friedewald	Michael	Fraunhofer ISI	Competence Center Emerging Technologies
Klenner	Karsten	BMUV	G II 1/Fundamental Social Policy Issues

Table C3

Future workshop participants (13 January 2022)

Last name	First name	Institution	Department/Position
Beckert	Bernd	Fraunhofer ISI	Competence Center Emerging Technologies
Bendszus	Rafael	BMUV	T I 2/Environmental Information, Chief Data Officer, Artificial Intelligence
Brozus	Lars	German Institute for International and Security Affairs	Global Issues Research Group, Deputy Research Group Leader
Cuhls	Kerstin	Fraunhofer ISI	Competence Center Foresight
Eberling	Elisabeth	Fraunhofer ISI	Competence Center Sustainability and Infrastructure Systems
Emmer	Martin	Free University of Berlin/Weizenbaum Institute	Professor/Principal Investigator (PI)
Erdmann	Lorenz	Fraunhofer ISI	Competence Center Foresight
Friedewald	Michael	Fraunhofer ISI	Competence Center Emerging Technologies
Fritsch	Peter	BMUV	G II 3/Regional Planning, Building Law, Rural Development
Gebauer	Jochen	BMUV	G I 2/Interdisciplinary Environment Law/Planning Acceleration
Ginzky	Harald	UBA	II 2.1/Overarching Water and Soil Matters
Gotsch	Matthias	Fraunhofer ISI	Competence Center Sustainability and Infrastructure Systems
Guggenheim	Felix	BMUV	G III 3/Sustainability Policy and Citizen Involvement
Gutknecht	Ralph	Fraunhofer ISI	Competence Center Foresight
Haake	Nels	German Federal Chancellery	Unit 611 Political Planning and Strategic Foresight
Hardach	Felix	BMUV	T III 1/Fundamental Strategy and Law Matters in Climate Change Adaptation

Last name	First name	Institution	Department/Position
Kettenburg	Annika	BMUV	T I 2/Environmental Information, Chief Data Officer, Artificial Intelligence
Kimpeler	Simone	Fraunhofer ISI	Competence Center Foresight
Klein	Maike	Gesellschaft für Informatik e. V. (GI) (German Informatics Society)	Public Security Research Forum
Löwe	Christian	UBA	Z 2.3 / Digitalisation and environmental protection, e-government
Koller	Matthias	UBA	I 1.1/Fundamental Issues, Sustainability Strategies and Scenarios, Resource Conservation
Neßhöver	Carsten	UBA	PB 1/Presidential Department/Head of the UBA International Academy Transformation for Environment and Sustainability Project Group (TES Academy)
Peperhove	Roman	FU Berlin	Public Security Research Forum
Rörden	Jan	Fraunhofer ISI	Competence Center Foresight
Roth	Florian	Fraunhofer ISI	Competence Center Policy and Society
Schirrmeister	Elna	Fraunhofer ISI	Competence Center Foresight
Theiler	Olaf	German Armed Forces Planning Office	Head of the Future Analysis Unit
Trier	Eva	future impacts	Strategy Consulting Associate
Ullrich	Stefan	Weizenbaum Institute for the Networked Society	Speaker at ZUG’s AI Ideas Workshop for Environmental Protection
Veenhoff	Sylvia	UBA	I 1.1/Fundamental Issues, Sustainability Strategies and Scenarios, Resource Conservation
Vollmer	Lukas	BMUV	T I 2/Environmental Information, Chief Data Officer, Artificial Intelligence
Zweck	Axel	RTWH Aachen	Honorary Professor of Innovation and Future Research

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