ETC ST Report 2024/5

Horizon Scanning 2024

Results of the EEA – Eionet participatory horizon scan to identify emerging issues relevant to the environment and environmental policy

Authors:

Sylvia Veenhoff (UBA GE), Ullrich Lorenz (4Strat), Ana Keser (4Strat), Tereza Kochová (CENIA)

European Environment Agency
European Topic Centre
Sustainability transitions

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EEA project managers: Ana Jesus, Celine Bout

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1 Why is it important to scan the horizon?

The current socio-political environment presents a context of continuous and pervasive change. The 2020 global pandemic was a stark reminder of the potential dangers of infectious diseases, while the conflict in Ukraine is one example of the risks associated with armed conflict. In recent years, there has been a marked increase in global inequalities, accompanied by a growing sense of injustice, a decline in trust, and the spread of divergent ideologies. All this has occurred against a backdrop of rapid technological change, rising prices and inflation, food and energy insecurity, and the proliferation of disinformation campaigns in all areas of human activity. In the context of these crises, there has been a marked deterioration in key earth systems that are essential for maintaining global climate stability and human civilisation (Möller et al., 2024). All these changes are particularly relevant from an environmental perspective, even though they have different impacts and levels of impact.

Regarding environmental policy, it is important to navigate the complex landscape of perceived changes, diffuse signals and opinions to identify those developments that might be relevant from an environmental point of view. The time factor is particularly important here: the earlier policymakers are aware of these changes, the earlier policy action can be taken (anticipatory governance). The development of mobile phones, for example, shows how supposedly niche technologies can quickly become mainstream, fundamentally change our way of life, contribute to environmental pollution (e.g. coltan mining and e-waste) and enable sustainable practices (e.g. the sharing economy).

The need for urgency cannot be overstated (EEA, 2019). The early identification of emerging developments is essential in enabling sustainability transitions in Europe. Such developments include social, technological, economic, environmental and political developments – such as emerging innovations, attitudes and lifestyles, emerging markets and business models, policy and legislative developments and innovations – that can present opportunities, risks and or ambivalences for the environment and sustainability transformation processes.

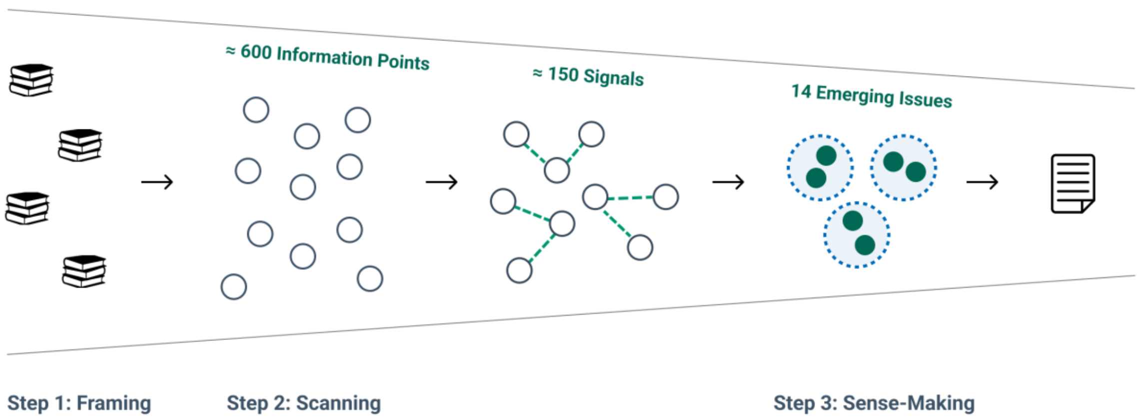
2 The horizon scanning approach

This report presents 14 emerging issues or developments identified through a horizon scanning process conducted between March and August 2024 with experts from the European Environment Agency (EEA) and its country network, the Eionet, and a few external experts. The process aimed to strengthen foresight capacity within the EEA and the Eionet, promote mutual learning, and build anticipatory knowledge to inform policy-making processes at the national and EU levels.

Horizon scanning for environmental policy is a structured process to systematically identify emerging developments that could be highly relevant to the environment but are not yet found in current-day research or media and are not (yet) on the political agenda (EEA, 2023; UBA, 2020). By having information on emerging developments at an early stage, decision-makers, such as the European Commission, the national ministries for the Environment, or the national environmental agencies in Europe, can improve their strategic ability to act and respond more proactively to future threats and make better use of opportunities to improve the state of the environment. The horizon scanning process leading to this report followed a structured approach comprising three main steps that are described in sections 2.1 to 2.3 (Figure 1):

1. **Framing of the scan**: The framing phase aims to structure the scan systematically and determine where to look for information indicating potential change.
2. **Scanning for information**: The scanning phase involves collecting and analysing information from various sources to identify early signs of change (weak signals).
3. **Sense-making and assessment**: The final phase involves evaluating and prioritising the weak signals identified, e.g. by clustering. This phase looks at the weak signals gathered during the scanning process from a cross-cutting perspective and ensures that they are interpreted in terms of their environmental relevance and translated into policy-strategically relevant insights known as emerging issues.

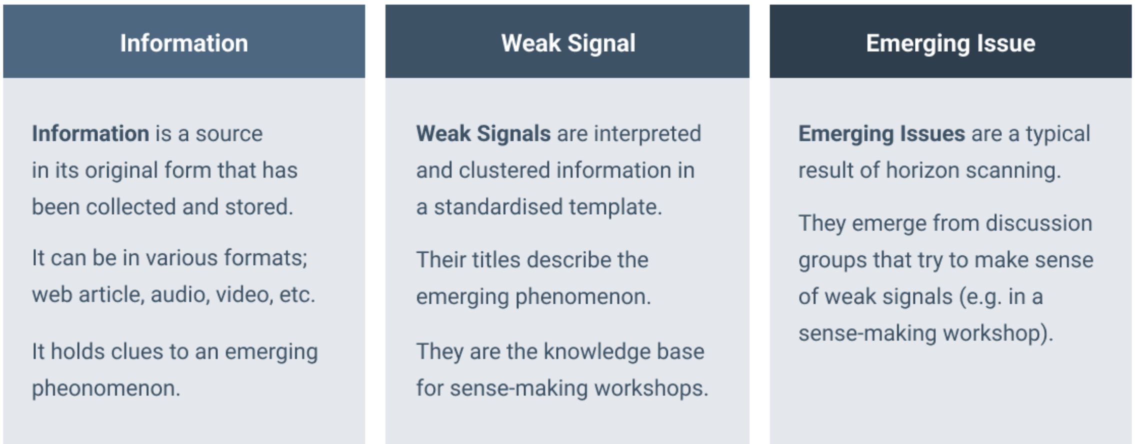
Figure 1: The horizon scanning process



Source: Own representation

The terms ‘information’, ‘weak signal’, and ‘emerging issue’ have specific meanings in the context of horizon scanning. Since these terms can be interpreted differently in different contexts and organisations, Figure 2 below describes how they were used in the process.

Figure 2: Key terminology used in this horizon scanning



Source: Adapted from EEA (2023)

The Foresight Strategy Cockpit (FSC), a modular online tool designed to facilitate strategic foresight processes, supported this horizon scanning process. The FSC allows users to browse and highlight relevant information from RSS feeds or capture data from any web page and serves as a robust support and storage system for scanning activities. Any raw data, including news articles, blog posts, web pages, or scientific journals, can be stored as a 'fact sheet' within the FSC. Each fact sheet contains the source, links, an image, a brief description, and information about the user who added it. Users can also add comments to provide additional context.

Factsheets can be linked together to form weak signals. These weak signal templates include a title, brief description, relevant tags, a categorisation (which in this project was done according to the STEEP framework and the EEA-Eionet work areas; see Figure 3), and links to related information. Administrators have the flexibility to add additional sections to enhance weak signals as needed.

Similarly, emerging issues can link to a cluster of various weak signals. Although this linkage is manual and not automated, an emerging issue can be linked to one or more weak signals within the FSC.

2.1 Step 1: Framing of the scan

The framing phase aims to frame the scan and determine where to look for signals. This step involved identifying the project's focal issue or research question and deciding what sources could provide this information. Such sources should cover information beyond the usual scientific channels, including mainstream media, news, arts, blogs, conferences, and social media.

The scan aimed to identify emerging developments of relevance to the environment and environmental policy in Europe by encouraging the scanning team to ask the question:

- ***What new worries or excites you because it could impact the environment in one or more of the five work areas of the EEA-Eionet Strategy?***

Figure 3: EEA-Eionet work areas as scanning fields

Source: Adapted from EEA (2021)

2.2 Step 2: Scanning for information

The scanning process can be conducted by a team of specialists with varying expertise on the topic(s) being scanned or by automation through techniques such as text mining that enable the examination of large data sets. Expert-based scanning and automated scanning can also be combined.

The scanning for information was conducted by a heterogeneous scanning team with backgrounds spanning the environmental and social sciences, using a simple, quick-to-complete template to gather new and environmentally relevant information. Participants reviewed a range of sources to gather information, including news articles, academic papers, journals, blogs, forums, early research reports, and social media. They were encouraged to consider information no older than 2023 relevant to one or more of the work areas of the EEA-Eionet Strategy.

The scanning yielded 800 information cards across all the STEEP categories and work areas. The project team then analysed these information cards and created weak signals based on this information. Weak signals are emerging phenomena that indicate that change is underway (EEA, 2023). All weak signals were listed in a signal catalogue and shared with participants to inform the discussions at the online sense-making workshops.

2.3 Step 3: Sense-making and assessment

The sense-making process often involves one or more participatory workshops. These workshops foster creative thinking and collaboration between experts with different areas of knowledge, including foresight, to analyse signals and identify emerging issues. An emerging issue refers to a new topic, a shift in perspective, or increased awareness concerning the focus area.

In this project, a total of five workshops were carried out. The first workshops focused on a specific EEA-Eionet work area (Figure 3). During these four sense-making workshops, participants analysed weak signals with potential impact on the respective work area, formed signal clusters, and identified potential emerging issues and their implications on the environment. Participants were then asked to vote for their top five clusters. After the workshop, the project team refined the emerging issue clusters by adding a title, description, and corresponding signals in the FSC tool. As a result of the four workshops, a list of 20 draft emerging issues (the top 5 from each workshop) formed the basis for a cross-cutting workshop at the end of the series.

The cross-cutting workshop aimed to look at the 20 draft emerging issues from a cross-cutting perspective and to further enrich them by adding to their descriptions, including a reflection on opportunities and risks for the environment. In the second part of the workshop, participants identified clusters of disruptive changes arising from the issues identified and explored implications for sustainability transitions as a whole.

Subsequently, the project team integrated the results of all workshops and refined them based on literature research to arrive at the 14 emerging issues presented in this report and the reflections on strategic implications for environmental policy presented in chapter 4, Conclusions.

3 Emerging issues 2024

This report presents 14 emerging issues or developments spanning the social, technological, economic, ecological, and political realms. These issues or developments can potentially impact one or more of the EEA-Eionet work areas outlined above. The topics presented are deliberately brief to reflect their diversity. Future research projects may involve in-depth analyses of selected topics.

Each emerging issue is presented according to the following structure:

- Title of the emerging issue
- Brief description of the emerging issue
- Selection of underpinning weak signals, each consisting of:
    - Brief description of the signal
    - Description of the implications on the environment and/or the work areas
    - List of links to the information sources used

Figure 4: Overview of the 14 emerging issues

01	**Global shifts and their effects on sustainability transitions**	**08**	**Out of sync with nature**
02	**AI: Promises and perils for sustainability**	**09**	**Social polarisation: New dynamics with impact on environmental policy**
03	**Environmental communication: Integrating the full range of approaches**	**10**	**Human Hubris: The rise of techno-biological engineering**
04	**From seabed to space: Tapping into untouched resources**	**11**	**Europe's dual challenge: Demographic shifts & their effects on the future of work**
05	**Mental & emotional exhaustion: Environmental & socio-economic stressors affecting well-being**	**12**	**Shifts in the food production & supply: New potentially sustainable alternatives**
06	**A synthetic world - from plastics to persistent chemicals**	**13**	**Water: A ticking time bomb for sustainability**
07	**Hidden emissions: The direct and indirect impacts of armed conflicts**	**14**	**New ways of construction: Lightweight, resource-efficient, climate change resilient**

Source: Own representation

3.1 Emerging issue 1: Global shifts and their effects on sustainability transitions

The geopolitical and economic landscapes constantly evolve, and new conflicts are emerging. The rise of China as a dominant economic and political force, deepening mistrust between countries, and rising geopolitical tensions are destabilising the current global order. This highly dynamic, complex and multifaceted domain of geopolitics encompasses a series of emerging and recent developments that profoundly impact the global economic, social and political landscape, even at the regional level, as the new round of EU enlargement in 2024 shows (EC, 2024a).

3.1.1 De-risking and re-industrialisation: Europe's response to global disruptions

The consequences of Russia's war against Ukraine, compounded by the stresses of the COVID-19 pandemic, have had far-reaching effects on global trade and the European economy. These effects include the disruption of global supply chains, blocked access to critical materials and a sharp rise in energy prices, which have particularly affected the EU. In response, a new era of de-risking and re-industrialisation is emerging, aimed at reducing the EU's dependence on imported resources, especially energy and critical raw materials.

This shift has significant implications for sustainability transitions. As Europe seeks to diversify energy sources and reduce dependence on fossil fuels from politically unstable regions, there may be an accelerated push towards renewable energy, energy efficiency and the circular economy. However, the rapid shift towards reindustrialisation and reshoring could pose sustainability challenges if the EU lacks access to raw materials essential for developing and producing clean energy technologies or advanced electronics. Global shifts in trading blocs and alliances, such as the decline in trade between the US and China and the collapse of trade between Russia and the West, could further affect the flow of sustainable technologies and raw materials needed for green transitions.

Economic fragmentation could go hand in hand with political fragmentation and lead to a 'nationalisation' of sustainability, with national governments developing responses to global challenges based solely on their national threat assessments.

- The global chessboard: a world in flux. Global trends to 2040 (espas.eu)
- Geopolitics and its impact on global trade and the dollar (imf.org)
- Sustainability in the age of geopolitics (europa.eu)
- Competitiveness of the European economy - statement of the Eurogroup in inclusive format (Eurogroup.eu)

3.1.2 The global war of subsidies in the green transition

The "global war of subsidies" involves countries like the United States, China, and the EU aggressively competing to promote clean energy and green technologies through financial incentives. The United States's Inflation Reduction Act (IRA) offers massive subsidies to green industries. The EU and China also subsidise renewable energy, electric vehicles, and battery production, leading to global tension over trade advantages and concerns about protectionism. For example, the United States and the EU have expressed their concern to China that Chinese subsidies threaten their green industries and have announced that they will respond with import restrictions. This competition influences global supply chains and investment patterns. It seems that the EU has yet to find its role in this competition for these future sustainable technologies.

- The global war of subsidies (policycenter.ma)
- Don’t fret about green subsidies (diplomaticourier.com)
- EU says china EVs funded by subsidies, plans retroactive tariffs (asiafinancial.com)

3.1.3 Growing polarisation of climate change and environmental discourses

Public opinion on climate change and environmental issues is increasingly polarised, particularly along political lines. Left-wing voters are generally more concerned about climate change and the environment, while right-wing voters are more sceptical. Various factors, such as age, education, income, and urban/rural residence, play a role in developing these views.

Polarisation affects environmental decision-making. In addition to people having different views on environmental issues, polarisation can negatively impact environmental decision-making, for example, by reducing the willingness to support climate change policies, engage in pro-environmental behaviour, or discuss environmental issues with others.

- Growing polarisation around climate change on social media (Nature.com)
- Environmental decision-making in times of polarisation (Annual Reviews.org)

3.2 Emerging issue 2: AI: promises and perils for sustainability

Artificial Intelligence (AI) offers significant opportunities to advance environmental sustainability. For example, it can help improve recycling processes, increase energy efficiency across sectors, or support biodiversity monitoring.

However, as awareness of AI's energy consumption increases, its image as a panacea for environmental challenges needs critical examination. While accurate estimates of AI systems are difficult to obtain, consulting firm Gartner suggests that by the end of this decade, Gen AI's energy demand will reach 3.5% of global consumption, posing a serious challenge to climate goals through increased electricity consumption and CO_2 emissions. The expansion of AI infrastructure, which relies heavily on minerals such as copper, further complicates the issue with concerns about resource extraction and degradation. The prevailing optimism about AI's role in solving environmental problems may obscure questions about its necessity, effectiveness, and the equitable distribution of its benefits. There is growing concern that the potential benefits of AI may be overstated, particularly if the technology is driven primarily by capitalist interests. Current discourse often frames AI as a technological solution without addressing the socio-political transformations required for true sustainability. Such a focus could entrench existing inequalities and environmental damage rather than address them.

3.2.1 AI in recycling and waste management

AI is improving recycling practices by automating the sorting process, significantly increasing efficiency, accuracy, and safety while reducing the need for human intervention. Progress is particularly evident in chemical recycling, where AI-powered systems extract and reuse materials efficiently from waste streams. By minimising reliance on virgin raw materials and substituting petrochemicals in manufacturing, these processes reduce carbon emissions, air, water and soil pollution and biodiversity loss.

In industrial recycling, AI-powered robots change how waste is sorted and processed. These robots use machine learning and advanced vision systems to identify and separate different types of waste at high speed and with remarkable accuracy. This speeds up recycling operations and improves the quality of recovered materials. The potential for further innovations, including bio-inspired robots for marine waste management, suggests even broader applications in environmental protection. AI is also making significant advances in fashion recycling, enabling the rapid identification and categorisation of textiles. This capability is critical to addressing the growing challenge of textile waste in landfills.

Despite these advances, integrating AI into recycling and manufacturing presents challenges. These include ensuring data availability and quality and addressing security concerns around sensitive data, such as collection routes and user behaviour. Overcoming these challenges is critical to realising AI's full potential benefits in creating a more sustainable and efficient circular economy.

- Recycling robots (Startus insights.com)
- Jellyfish-like robots could one day clean up the world's oceans (Techexplore.com)
- Could the Next Generation of Man-Made Fibres Fast-Track the Transition to Circular Fashion? (Euromonitor.com)
- Smart waste management: A paradigm shift enabled by artificial intelligence (Sciencedirect.com)

3.2.2 Using AI to safeguard biodiversity

AI and advanced mapping technologies may prove useful in addressing the biodiversity crisis. These technologies, which include remote sensing, AI algorithms, and statistical modelling, enable high-tech maps to track species' current locations and predict their future movements. For example, supercomputers and geographic information systems can track the migrations of plants, birds, and mammals. This data enables countries to develop more informed conservation strategies that consider the dynamic effects of climate change.

In addition, AI-powered threat detectors use advanced sensors and cloud-based AI analytics to monitor wildlife habitats for potential threats. For example, smart buoys with bioacoustic sensors detect marine mammal sounds and send them via the cloud for AI analysis, generating knowledge about their behaviour and how it might be affected by noise pollution. Similarly, devices equipped with microphones and antennas can, through AI-powered analytics, detect threats such as illegal logging or poaching and alert conservation authorities in real-time.

- From AI to robot jellyfish, here's the technology protecting biodiversity (weforum.org)

3.2.3 AI's thirst for energy, water, and critical raw materials

The exponential growth in computing power required to support AI has led to a corresponding increase in energy consumption. The World Economic Forum suggests that by 2028, AI could consume more electricity than Iceland consumed in 2021 (WEF, 2024), while Gartner calculates that at current growth rates, AI will consume 3.5% of the global energy by 2030, about twice that of France. Training AI models such as GPT-3 require significant computing resources, consuming up to 1,287 MWh of electricity and generating significant CO_2 emissions (The Brussels Times, 2024).

Energy demand is driven by the need for high-speed supercomputers and extensive cooling systems, making processor consumption a critical metric. For example, cooling systems for servers running AI models consume significant amounts of water: up to half a litre evaporates for every 20 to 50 queries, the equivalent of a small bottle of water per conversation (Gendron, 2023). AI's projected water usage could hit 6.6 billion m^3 by 2027, signalling a need to tackle its water footprint (Gordon, 2024).

As AI technology, particularly data centres and AI training models, continues to grow, the resource demand has increased significantly. In this context, there has been a noticeable shift in the discussion of problems due to critical mineral resource demand from electric vehicles (EVs) to artificial intelligence (AI). For example, according to commodity trader Trafigura, the expansion of AI by 2030 is expected to require an additional million tonnes of copper (Begert, 2024).

- How to manage AI's energy demand — today, tomorrow and in the future (weforum.org)
- ChatGPT consumes 25 times more energy than Google (brusselstimes.com)
- AI Power Consumption: Rapidly Becoming Mission-Critical (forbes.com)
- Rethinking Concerns About AI's Energy Use (datainnovation.org)
- ChatGPT needs to 'drink' a water bottle's worth of fresh water for every 20 to 50 questions you ask (businessinsider.nl)
- Electric vehicles - AI needs critical minerals (politico.com)

3.2.4 Sustainable AI – yet another technology reinforcing a non-sustainable world?

A critical analysis of sustainable AI reveals how it is likely to function primarily to serve existing systems of exploitation and exclusion. Although designed to address climate, circular economy, biodiversity and other sustainability issues, sustainable AI remains rooted in the imperatives of capitalism and techno-solutionist ideologies. For example, economic exploitation in AI is evident in how data and capital are linked and how big tech companies prioritise profit over ethical and sustainability concerns. Environmental exploitation is seen in the high levels of energy consumption and resource extraction required for AI technologies, while social exploitation of AI involves the intrusion of people's privacy and social networks. This highlights a dilemma: AI tools embedded in an exploitative framework are being used to solve problems created by capitalism, thereby exacerbating the problems they seek to solve.

Despite AI's potential to offer valuable environmental solutions, the significant social, economic, and environmental costs demonstrate that sustainable AI solutions may be fundamentally flawed. Relying on an inherently exploitative system to address environmental issues is problematic and suggests that the ideology of sustainable AI masks deeper problems. To achieve true sustainability, alternative approaches that do not rely on exploitative systems must be considered.

- The Problem of Sustainable AI (weizenbaum-institut.de)
- AI has an environmental problem. Here’s what the world can do about that (UNEP.org)
- AI, Sustainability, and Environmental Ethics (Springer.com)

3.3 Emerging issue 3: Environmental communication: integrating the full range of approaches

The current approaches to communicating unprecedented issues linked to climate change do not yet fully convey their novel and discontinuous nature. Environmental communication strategies must include various perspectives and methods to promote sustainability and inspire action effectively. For example, new storytelling and information-sharing methods should be further explored. This includes the local level. Here, community-based journalism can play an important role in bridging information channels that rarely reflect the realities of local environmental issues. Additionally, incorporating insights from neuroscience and psychology and using immersive technologies such as virtual reality could help develop a broader comprehension of environmental challenges and stimulate greater engagement from the public.

3.3.1 Beyond linear narratives

In the modern era, making sense of change over time typically involves integrating new experiences into an ongoing story. Simon (2021) calls this 'temporal domestication', a way of making sense of new phenomena by placing them within a broader, ongoing framework or process. One mechanism for this is to describe these phenomena using familiar and broad categories until they lose perceived novelty. Another is using temporal markers to connect current and past events, creating a sense of continuity. This approach can help make certain efforts across time, such as social movements, appear more feasible since they build on previous events. However, it can also be potentially dangerous for phenomena disconnected from past experiences and need to be recognised and addressed. In this case, temporal domestication can lead to less agency.

– Domesticating the future through history (sagejournals.com)

3.3.2 Psychology and neuroscience for environmental communication

The fields of neuroscience and psychology may offer new ways to improve the communication of environmental issues, thus making it more effective and impactful. By studying the effects of climate change on the human brain and behaviour, these disciplines can help develop more advanced environmental-related strategies, understand decision-making processes better, and inform the development of more effective communication techniques. For example, understanding cognitive biases (such as focusing on the short-term or the inertia to change the status quo) can help tailor messages that encourage pro-environmental behaviours.

– Leveraging neuroscience for climate change research (nature.com)
– Psychology and Climate Change: Some Need-to-Knows (psychologytoday.com)

3.3.3 Awareness through intelligent digital visualisation

Virtual reality (VR) and intelligent digital visualisations create immersive experiences that allow individuals to engage directly with the challenges and impacts of climate change. Initiatives like the Eden Project's Dear Earth use these technologies to induce emotional responses and foster deeper connections with environmental issues. Meanwhile, simulations based on environmental data allow policymakers to explore climate impacts more vividly and test adaptation strategies in virtual environments.

These visualisation approaches can help reshape environmental communication by bridging the gap between scientific data and public awareness. By immersing users in realistic scenarios, VR and digital visualisations can enhance understanding of complex environmental issues and inspire action.

- ‘It’s positive, not apocalyptic’: can climate change art help save the planet? (theguardian.com)
- Virtual reality games offer visceral taste of a climate-changed future (eco-business.com)

3.3.4 Local storytelling for environment information gaps

Local journalists and community-based media entrepreneurs can help ensure that local stories are covered and diverse voices are heard by filling the information gap left in some cases by national and international newspapers. Beyond providing information, they can help foster a sense of community and civic engagement by focusing on the specific needs and interests of those who live and work in those communities.

More specifically, local journalism could be important in informing and engaging people on environmental issues, such as mitigation and adaptation to climate change or biodiversity loss, by publishing information directly related to a given place or geographical area. This is particularly needed in places where specific environmental issues might be underreported, and their global and local drivers are not clearly known.

- Community-based entrepreneurs are leading the way in solving the local news crisis (theconversation.com)
- Blind Spots: How self-censorship impacts local journalism in Germany (ecpmf.eu)
- The importance of local journalism to understanding the UK riots (indexoncencorship.org)
- Local journalism is a critical “gate” to engage Americans on climate change (news.mit.edu)

3.4 Emerging issue 4: From seabed to space: Tapping into untouched resources

The pursuit of metals and minerals is moving to new frontiers: the deep sea and outer space. Driven by rising demand for these crucial materials, technological advancements make resource extraction in these remote and extreme environments more feasible. This evolution offers substantial opportunities, such as access to new mineral deposits and reduced terrestrial mining pressures. However, it also introduces significant risks, including environmental degradation and ecosystem disruption. Moreover, the ethical and regulatory frameworks governing these activities are still evolving, with ongoing international debates regarding ownership and exploitation in these domains. The delicate balance between exploiting these untapped resources and ensuring environmental sustainability and socio-economic equity will shape the future trajectory of this emerging issue.

3.4.1 Increasing spotlight on deep-sea mining

The deep sea is one of the last regions on earth largely untouched by humans. Exploiting mineral resources from deep-sea deposits could become more important due to rising metal prices and greater demand, but it has environmental implications. Deep-sea mining can cause irreversible destructive impacts on fragile deep-sea ecosystems and biodiversity, including habitat loss and fragmentation, killing and extinction of rare and geographically restricted species, disruption of ecosystems' functions, impairment of feeding and reproductive behaviours, and disruption of food chains with unpredictable and possibly severe consequences for fisheries, livelihoods, food security and ocean biogeochemical cycles.

- Deep-sea mining (umweltbundesamt.de)
- What We Know About Deep-Sea Mining — and What We Don't (wri.org)
- Deep-sea mining poses an unjustifiable environmental risk (nature.com)

3.4.2 Rise of the human efforts in space

The way humans endeavour to outer space is currently undergoing significant change and is highly dynamic. This is due, among other things, to the "new space" trend, i.e. the shift of space activities from government to the private sector. As a result, the number of rockets and satellites in space is increasing while the costs of space services are decreasing.

As space activities grow, so do the environmental impacts on Earth and space, creating new problems and risks. On Earth, activities include constructing and operating ground infrastructure such as launchers and payloads, training and research centres, test facilities and data receiving and transmitting stations, as well as producing and operating technical systems such as satellites, rockets, space probes and space stations. It also includes emissions from rocket engines and fuels, the generation of space debris (see 3.4.3) and chemical pollution of the Earth's atmosphere.

- Human endeavour in space (umweltbundesamt.de – will be published in March 2025)
- In new space race, scientists propose geoarchaeology can aid in preserving space heritage (phys.org)
- Earthworm robots could help astronomers explore other worlds (astronomy.com)
- Why on earth should business care about space? (mckinsey.com)

3.4.3 Space debris - risks and consequences

With the increasing number of rocket launches and satellite systems, a significant amount of material will burn up in the Earth's atmosphere or remain in space.

Removing existing space debris and binding regulations for new objects launched into space are necessary for environmental protection. However, space debris must also be removed to avoid collisions with satellites or the International Space Station (ISS), which would have unforeseeable consequences for space travel, communication, and other space services on Earth. The time window for future rocket launches is getting smaller and smaller due to the increasing amount of space debris, and thus, the scope for future generations in space is being restricted. In addition, astronomers are increasingly concerned about another effect of space debris: it brightens the night sky and makes observing the universe more difficult by reflecting sunlight and illuminating the sky.

Although political instruments exist to address the problem of space debris, the implementation of the goals and their voluntary nature have not been sufficient. To control the current situation in the Earth's orbit, it is necessary to ban new space debris and monitor, dispose of, recycle or reuse existing space debris. Various business models for this are currently emerging.

- Human endeavour in space (umweltbundesamt.de – will be published in March 2025)
- Sustainability in space—can you teach old satellites new tricks? (phys.org)
- Bright satellites are disrupting astronomy research worldwide (nature.com)

3.5 Emerging issue 5: Mental & emotional exhaustion: Environmental & socio-economic stressors affecting well-being

The contemporary psychosocial landscape is marked by higher levels of emotional and cognitive exhaustion. Growing ecological and climate anxiety, the psychological impacts of pollution, and the erosion of cultural heritage and community identity reflect feelings of alienation and vulnerability that manifest in response to overwhelming and often deteriorating circumstances.

As environmental and climate-related disruptions become more frequent, their psychological and emotional impacts will likely become more pronounced. Moreover, economic instability can add to feelings of insecurity and helplessness. Digital platforms, through algorithmic bubbles, digital isolation, and the influx of low-quality and highly repetitive media, can increase mental fatigue and disengagement, thus exacerbating existing problems rather than offering solutions. A systemic understanding of the causes and psychological consequences of this global mental health crisis is fundamental to help address it.

3.5.1 Eco-anxiety and climate-related distress

Environmental and climate anxiety has become a pressing issue among younger generations. A study by the Czech National Institute of Mental Health from 2023 found that 62% of 16–25-year-olds experience significant anxiety about climate issues, with 67% reporting feelings of sadness and fear. This heightened emotional response stems from immediate environmental disasters and a pervasive sense of ongoing crisis. Intensified climate events, such as extreme weather, contribute to chronic alarm and can lead to psychological distress, including post-traumatic stress disorder (PTSD). In addition, declining confidence in governments' and institutions' ability to address the climate and biodiversity crises exacerbates feelings of helplessness.

- Youth Anxiety 'Epidemic' Shows Need for Paradigm Shift in Czech Mental Healthcare (balkaninsight.com)
- Repeated extreme weather events linked to rise in mental health problems, trauma (theglobeandmail.com)

3.5.2 Destruction of cultural heritage and community identity

Loss and anticipated loss of cultural heritage sites from climate-related disasters and conflicts can profoundly impact community identity. These events can cause physical damage to historic buildings, monuments, and archaeological sites and disrupt cultural practices vital to community cohesion. The loss of both tangible cultural assets, such as artefacts and architectural treasures, and intangible assets, such as traditions and rituals, intensifies psychological distress and fosters a deep sense of disconnection among affected communities. This erosion of cultural heritage exacerbates feelings of alienation and highlights the urgent need for integrated strategies to preserve and protect community history and identity.

- Will COP28 deliver a new fund for climate loss and damage? (news24.com)

3.5.3 *Digital overload and information fatigue*

The constant stream of crisis-related information can overwhelm people, causing them to become disengaged from taking meaningful action. Additionally, economic and political interests influencing media stories can erode trust in traditional news sources. The rapid rise of low-quality, AI-generated content further complicates matters. This flood of unreliable information on the internet obscures trustworthy sources, making it harder for the public to trust and make informed decisions.

- AI is killing the old web (theverge.com)

3.5.4 *Air pollution may cause cognitive decline*

New research links air pollution to accelerated cognitive decline. Long-term exposure to pollutants such as nitrogen dioxide is associated with faster cognitive decline and increased use of mental health services. This suggests that air pollution may exacerbate neurological conditions and contribute to new cognitive impairments. Actions to improve air quality could have significant benefits for cognitive health and overall mental well-being.

- Associations between air pollution and mental health service use in dementia (mentalhelth.bmj.com)

3.6 Emerging issue 6: A synthetic world - from plastics to persistent chemicals

In recent decades, introducing synthetic substances, including chemicals and plastics, into industrial processes and consumer products has created complex human health and environmental challenges with significant uncertainties. These substances are now ubiquitous in ecosystems and human bodies, revealing a worrying gap between our understanding of their long-term effects and their actual impact.

To address the risks these synthetic substances pose, it is essential to prioritise in-depth assessments of their safety and sustainability and to focus on closing the knowledge gap regarding their long-term effects on health and the environment. This requires applying concepts such as ‘essential use’ (to ensure that the most harmful chemicals are only allowed if they are essential for society and there are no acceptable alternatives) and the ‘precautionary principle‘. Nevertheless, our limited understanding of how harmful chemicals really are and how difficult it is to properly govern the impacts of chemicals remains a fundamental challenge.

3.6.1 Plastics in the air may change weather patterns

In recent years, research has shown that microplastics pose risks to humans (through food consumption and inhalation) and ecosystems, especially in the marine environment (Thacharodi et al., 2024). What is hardly known so far is that microplastics are also found in clouds and may influence the weather. Their presence in clouds can affect cloud formation, alter precipitation patterns, and influence local and global climate dynamics. This unexpected interaction between airborne plastics and meteorological processes raises concerns about their broader impacts on weather systems and climate stability.

- Microplastics found in clouds could affect the weather (acs.org)
- "Plastic rain" is now a real thing as airborne microplastics are discovered in clouds (earth.com)
- Microplastics Are Filling the Skies. Will They Affect the Climate? (e360.yale.edu)

3.6.2 PFAS: 'The precautionary principle has failed'

Per- and polyfluorinated alkyl substances (PFAS) are chemical compounds that have become indispensable in many products, such as cookware, packaging and outdoor clothing, due to their water-, grease- and dirt-repellent properties. However, their extreme persistence in the environment and harmful effects are increasingly becoming a global problem. The precautionary principle, which should prevent the proliferation of such harmful substances, has failed since the danger posed by PFAS has long been ignored. Billions of dollars in lawsuits are currently being filed against companies such as 3M, and stricter regulations are being debated worldwide. Innovations are urgently needed to replace PFAS with safer alternatives, monitoring systems to determine the level of contamination, and effective methods to clean up contaminated sites (from soil, water, etc.) without further polluting the environment.

– PFAS: 'The precautionary principle has failed' (naturschutz.ch)

3.6.3 Toxic materials resulting from plastic recycling processes

The growing volume of plastic waste has highlighted troubling issues with recycling processes, such as releasing hazardous "forever chemicals" into water sources (e.g. Susquehanna River in the US). These persistent toxins can seep into ecosystems and pose public health risks. As waste volumes increase, more effective recycling methods and regulations to manage toxic materials are critical. Improving our understanding of their impacts and refining technological and regulatory approaches are essential to reducing the environmental and health risks associated with plastic recycling.

– Plastic recycling plant could send toxic 'forever chemicals' into the Susquehanna River, polluting a vital drinking water source (envnewsbit.info)

3.7 Emerging issue 7: Hidden emissions: The direct and indirect impacts of armed conflicts

The year 2023 saw the highest number of state-based conflicts since 1946 and registered the third highest number of battle-related deaths since 1989 (UCDP, 2024). Armed conflicts have devastating consequences on populations, economies and ecosystems. In addition to the loss of life, human suffering and displacement of populations, armed conflicts have significant and often overlooked environmental consequences, including greenhouse gas emissions, damage to biodiversity and ecosystems, pollution of soil and water, and the dumping of hazardous waste. Indirect environmental impacts include the rebuilding of infrastructure and the diversion of funds away from climate and other environmental problems (WGEA, 2022), (UN, 2024), (Weir et al., 2024).

Due to the advancing threat of climate change – which may lead to yet more conflicts – the intersection of military activities and climate change is an emerging area of concern. Military operations, particularly in times of conflict, contribute significantly to global greenhouse gas (GHG) emissions, with estimates suggesting that military activities are responsible for up to 5.5% of global emissions (Parkinson and Cottrell, 2022). Despite this, there is a gap in the mandatory and transparent reporting of these emissions, largely due to exemptions and lack of stringent requirements under international agreements such as the United Nations Framework Convention on Climate Change (UNFCCC). Military technology is also progressing rapidly, with drones, robotics and artificial intelligence playing increasingly tactical roles. Such technologies rely on a large amount of data processing and have a high energy and material demand. This points to the need to address military activities within the broader climate change discourse and negotiations.

3.7.1 Monitoring and attribution of military emissions

Significant data gaps limit the accurate measurement and reporting of military greenhouse gas (GHG) emissions. Without consistent reporting requirements and transparency, much data remains incomplete or hidden within broader civilian categories, leading to reliance on estimation methods instead of accurate measurements. The currently available estimates appear significant and thus call for more transparent and mandatory reporting of military emissions, as data gaps and the lack of standardised methodologies obscure the full environmental impact of military activities.

- Estimating the Military's Global Greenhouse Gas Emissions (sgr.org.uk)
- A Multitemporal Snapshot of Greenhouse Gas Emissions from the Israel-Gaza Conflict (papers.ssrn.com)
- Tracking unaccounted greenhouse gas emissions due to the war in Ukraine since 2022 (sciencedirect.com)
- Greening the armies (consilium.europa.eu)

3.7.2 AI-driven evolution of warfare

As artificial intelligence (AI) is increasingly integrated into military and non-military strategies, the nature of warfare is evolving. AI supports military strategies through rapid data processing, autonomous decision-making, and precision targeting. Additionally, hybrid warfare, which combines conventional tactics with cyber-attacks and misinformation, is increasingly driven by AI and can disrupt critical infrastructure, manipulate public opinion, and destabilise economies without direct military involvement. AI-driven military operations, including autonomous systems and data centres, contribute to greenhouse gas emissions – to be developed.

- Strategic Foresight Analysis 2023 (act.nato.int)
- The AI-powered, totally autonomous future of war is here (wired.com)

3.7.3 Rising sales and profits in the global defence industry

The global arms industry is experiencing unprecedented growth, with record order backlogs and surging sales, driven by ongoing conflicts such as those in Ukraine and Gaza. Leading manufacturers such as Rheinmetall have reported significant increases in sales and profits, underpinned by large military contracts and increased global demand for defence equipment. This trend reflects a wider industry shift as geopolitical tensions continue to generate significant economic benefits for arms manufacturers.

Beyond the economic and security implications, however, this surge in military production raises critical concerns. The environmental impact of increased arms production is significant, as the industry contributes to greenhouse gas emissions, resource depletion and pollution. From the extraction of raw materials, energy-intensive production processes, and environmental damage caused by military activities, the expanding defence sector poses serious challenges to global sustainability efforts. These developments highlight the complex intersection of economic interests, security imperatives and environmental responsibility in an era of increasing global conflict.

- World's top arms producers see revenues rise on the back of wars and regional tensions (sipri.org)
- German defence contractor posts near doubling in operating profits on higher military spending (ft.com)

3.8 Emerging issue 8: Out of sync with nature

Ecological evolution and changes in species composition and ecosystems are natural processes driven by gradual and long-term genetic adaptations that enable species to survive within their ecological niches. Human activities are impacting the Earth's biosphere and atmosphere at an unprecedented pace and scale, outpacing the capacity of species and ecosystems to adapt and eroding the planet's capacity to sustain life as we know it, including ecosystems' ability to provide services essential to meet human needs. This creates significant challenges (such as the spread of invasive species) and the necessity to find novel ways to respond, such as inclusive approaches to biodiversity conservation or the development of climate-resilient crops.

3.8.1 New methods to control invasive species

Various alien species of plants and animals are found and spread worldwide. Many of these non-native species, inadvertently introduced through the global movement of goods and people, compete for prey and habitat and can introduce new parasites and diseases. This issue is well exemplified by the invasive grey squirrels and crayfish, which displace native species and disrupt local ecosystems.

Many new ways exist to control invasive species, including gene editing techniques such as CRISPR. These advanced methods enable the precise targeting of genes crucial for the survival or reproduction of the invasive species. Scientists can engineer infertility or introduce traits that reduce the ability of these species to compete or thrive in new ecosystems. For instance, researchers are investigating the use of genetically modified semi-parasitic plants to control invasive plants in valuable meadow wetland habitats. These semi-parasitic plants can weaken the non-native species, creating the conditions for native, rare species to replace the invasive species.

- Scientists Explore Gene Editing to Manage Invasive Species (usda.gov)
- Exotic spiders flourishing in Britain as new jumping species found in Cornwall (theguardian.com)
- First Confirmed Sighting of an Asian Hornet in the Czech Republic (czechdaily.cz)

3.8.2 Engineering plants in response to climate change

As climate change threatens food security, new varieties of fruit and vegetables are being developed to adapt to changing environmental conditions. For example, genetically modified (GM) cherry trees now need about a third less cold weather. At the same time, GM cauliflowers are designed to withstand sunburn, so farmers no longer need to protect their crops by tying leaves together. In addition, GM melons with deeper root systems are better equipped to withstand drought. These innovations demonstrate the potential of GM crops to help mitigate the effects of climate change and offer a promising business opportunity for manufacturers.

However, the widespread use of GM crops raises concerns, many of which are not fully understood. These include the risk of cross-pollination, where genes from GM plants are transferred to wild plants and other crops, potentially disrupting natural ecosystems. Other risks include adverse effects on insects and other species, a reduction in biodiversity due to the dominance of GM plants, and possible allergic reactions in humans. These consequences highlight the need for careful consideration and regulation of GM crops to balance their potential benefits with their impacts on human health and the environment.

- New Varieties Of Fruits & Vegetables Are Fighting A Changing Climate (cleantechnica.com)
- Meet the Meet the Climate-Defying Fruits and Vegetables in Your Future (nytimes.com)
- Pros and cons of GMO foods: Health and environment (medicalnewstoday.com)

3.8.3 Need for inclusive approaches to biodiversity conservation

There is a need for inclusive approaches to biodiversity conservation because diverse stakeholders, particularly Indigenous peoples, bring essential knowledge, experience, and values crucial for safeguarding ecosystems. One key aspect of protecting nature and meeting policy targets is ensuring the full participation of local stakeholders in conservation and restoration efforts. To achieve the biodiversity target of the Kunming-Montreal Global Biodiversity Framework, which aims to ensure that by 2030, at least 30% of terrestrial, inland water, and coastal and marine areas are effectively conserved and managed, Indigenous peoples play a central role (Broom and North, 2024). This requires the full support of governments and international institutions, which must protect Indigenous communities from industrial and economic interests that may undermine conservation efforts. By integrating Indigenous perspectives and traditional ecological knowledge into global conservation strategies, we can foster more sustainable and effective approaches to biodiversity protection.

- Here’s how Indigenous people are protecting the planet (wef.com)
- The role of Indigenous peoples and local communities in effective and equitable conservation (iucn.org)
- A Guide to Inclusive, Equitable and Effective Implementation of Target 3, see p.63ff (worldlife.org)

3.9 Emerging issue 9: Social polarisation: New dynamics with impact on environmental policy

Social polarisation has emerged as a significant trend in Europe, reshaping the landscape of environmental policymaking. Polarisation and group identification are part of an open, pluralistic society and can be expressed differently. Issue-driven polarisation, for example, refers to the radicalisation of opinions, positions or beliefs on a specific topic within a group of like-minded people, whilst affective polarisation refers to a growing social-emotional distance between groups, characterised by mutual distrust and aversion (EC, 2024b), (Smith et al., 2024).

Social polarisation is driven by economic inequality, the media, the rise of digital communication technologies, and polarising political leaders.

Polarisation manifests as a growing divide between groups with differing values, ideologies, or socioeconomic conditions. It is intensifying in many countries, creating challenges in achieving societal consensus on climate change, social justice, and resource management. While polarisation may lead to intergroup conflict and hostility, creating substantial challenges for environmental policy, it can also help mobilise political ideas, foster activism, and contribute to social change.

3.9.1 Growing polarisation on environmental issues and values

There is growing evidence of societal polarisation around environmental issues and values in Europe and globally. The World Economic Forum's Global Risks Report 2024 highlights how increasing polarisation—driven by resource stress, conflict, and ideological divides—undermines resilience and exposes societies to heightened risks. In the EU, several political groups, industry lobbies, and EU member states have expressed opposition to key environmental legislation and policies, such as the Nature Restoration Law.

This polarisation poses significant challenges to building the political consensus and public mandate needed for ambitious environmental policies and action. Oppositional narratives that portray conservation efforts as a threat to livelihoods or as an elitist agenda can erode support for protecting critical habitats, sustainable land use management, and other measures. At the same time, polarisation can radicalise environmental activism, leading to disruptive protests that, even if well-intentioned, may alienate key stakeholders and impede constructive dialogue. As distrust deepens and opposing sides become entrenched, valuable time is lost in fighting against biodiversity loss. Environmental activists face growing demonisation and repression by public and private actors. Groups like Last Generation and Extinction Rebellion have been vilified and criminalised in several countries and labelled as "eco-terrorists" or "extremists" by politicians and the media. This framing often conflates non-violent activism with more confrontational tactics, which in turn are used by the authorities to justify mass arrests, infiltration, frozen bank accounts, and harsh anti-protest laws. Reports suggest coordinated efforts between governments, industries, and right-wing think tanks to promote anti-activist narratives and policies (Westervelt and Dembicki, 2023). These repressive measures risk stifling legitimate dissent and further exacerbate environmental issues' polarisation, making collaboration increasingly difficult.

- MEPs accused of ‘culture war against nature’ by opposing restoration law (theguardian.com)
- Bears, cars and angry farmers fuel green backlash (politico.eu)
- Polarization is the psychological foundation of collective engagement | Communications Psychology (nature.com)
- “Enemies of Society”: How the Media Portray Climate Activists (greeneuropeanjournal.eu)
- Human rights experts warn against European crackdown on climate protesters (the guardian.com)
- State repression of environmental protest and civil disobedience: a major threat to human rights and democracy (unece.org)

3.9.2 Digital technologies: advancing progress or exacerbating inequality?

While digital technologies such as artificial intelligence, algorithms, and social media promise progress and convenience, they can also facilitate the rapid spread of conspiracy theories, discriminatory ideologies, and hate speech and exacerbate existing biases and inequalities inadvertently. For example, AI systems used for urban planning can unintentionally prioritise wealthy neighbourhoods, exacerbating environmental inequalities, while algorithm-driven credit scoring can exclude marginalised groups from green finance initiatives.

These technologies are shaped by the values and biases embedded in them. Left unchecked, they can entrench unsustainable practices and deepen inequalities, undermining the inclusive principles necessary for effective environmental governance.

To promote meaningful change towards sustainability, it is crucial to use digital technologies to foster dialogue, strengthen social movements and ensure equitable access to resources and opportunities.

- Tackling Bias, Inequality, Lack of Privacy – New WHO Guidelines on AI Ethics and Governance are Released (healthpolicy-watch.news)
- Discrimination in the time of digital real estate: Illustrating a rental schema in the Australian setting (sciencedirect.com)
- More than a Glitch: Confronting Race, Gender, and Ability Bias in Tech – review | Impact of Social Sciences (lse.ac.uk)
- Growing polarization around climate change on social media (nature.com)

3.10 Emerging issue 10: Human Hubris: The rise of techno-biological engineering

Human hubris is the ambition to dominate and manipulate natural processes. Technologies like synthetic biology, geoengineering, drones, and the creation of artificial life forms are now at the forefront of efforts to control and reshape ecosystems.

Geoengineering initiatives aim to mitigate climate change by artificially altering Earth's atmospheric and climatic systems. Genome editing, particularly advancements in CRISPR technologies, allows unprecedented precision in altering the genes of plants, animals, and even humans, raising prospects and ethical questions about directed evolution and disease eradication.

Artificial life forms, meanwhile, have the potential to revolutionise fields ranging from agriculture to medicine but also pose unknown risks to existing ecosystems. In marine environments, desalination projects aim to address global food and water shortages. Eco-domes, or enclosed ecosystems created to sustain human life in space and extreme environments, represent humanity's growing capability to construct and maintain artificial living conditions away from Earth. This expresses an overarching desire to dominate that coexistence with nature and mould it to fit human needs and ambitions.

3.10.1 Synthetic biology on the rise

Synthetic biology intersects with robotics engineering using biological tissues, forming an emerging field known as techno-biological engineering. Synthetic biology may provide many solutions to environmental challenges such as climate change, sustainable management of natural resources, clean water provision and pollution reduction. However, it also creates substantial risks for ecosystems, e.g. by the intrusion of novel, synthetic organisms into the environment and their effects on biodiversity. This interdisciplinary domain leverages advances in synthetic biology, materials science, and information technology to develop hybrid systems that combine biological and synthetic components. Examples include biological robots, which integrate biological tissues with synthetic frameworks to create entities capable of complex functions. These innovations harness the scalability and versatility of synthetic biological methods alongside modern computational and material technologies.

Furthermore, developing smart, cytogenetic protocells supports using synthetic biology to engineer biological tissues in robotics. These cell-like bodies, constructed using synthetic biology techniques, can be embedded into robotic systems, providing enhanced functionalities such as sensing and adaptability. Combining synthetic biological methods with robotics opens new possibilities for creating advanced, multifunctional robotic systems that can interface seamlessly with biological environments.

- The technology, opportunities, and challenges of Synthetic Biological Intelligence (sciencedirect.com)
- Biological Robots: Perspectives on an Emerging Interdisciplinary Field (arxiv.org)
- Metal or muscle? The future of biologically inspired robots (science.org)
- Synthetic tissue engineering with smart, cytomimetic protocells (sciencedirect.com)

3.10.2 Desperate nations may unilaterally begin geoengineering the global climate

Solar geoengineering approaches are associated with major ethical, technical and political uncertainties and do not appear mature enough to be deployed safely and rapidly in the coming decades. There are also calls for governments to ban the commercial use of solar geoengineering, declare a moratorium on further use, and develop a multilateral system to regulate research and testing. Various government research arms are already gaming out scenarios, looking at who might decide to carry out climate engineering and how.

Climate engineering is expected to be cheap relative to the cost of ending greenhouse gas emissions. However, it would still cost billions of dollars and take years to develop and build a fleet of aeroplanes that would carry megatons of reflective particles into the stratosphere each year. Any billionaire considering such a venture would run out of money quickly despite what science fiction might suggest.

However, a single country or coalition of countries witnessing the harms of climate change could make a cost and geopolitical calculation and decide to begin climate engineering unilaterally. This is the so-called free driver problem, meaning that one country of at least medium wealth could affect the world's climate unilaterally.

- Desperate nations may unilaterally begin hacking the global climate (sciencealert.com)
- Governance of Earth system tipping points (global-tipping-points.org)

3.10.3 Next generation of drones

The next generation of drones is poised to revolutionise civil and military applications by mimicking the natural movements of birds and insects. Engineers and developers are increasingly drawing inspiration from biomechanics, creating ornithopters—aircraft that fly by flapping their wings. This innovative approach offers several advantages over conventional rotor-based drones, including quieter operation and more efficient manoeuvrability in complex environments like dense forests or urban areas.

In the military realm, these nature-inspired drones are particularly valuable for their stealth capabilities. For instance, the resemblance of these drones to biological entities makes them less conspicuous and potentially immune to standard detection methods used against traditional drones. An example cited is the dragonfly drone, already under development, which promises to significantly enhance the discreetness of aerial surveillance and reconnaissance missions.

On the civilian side, these advanced drones could be used for various tasks, from pollinating crops in agriculture to monitoring wildlife. Their ability to blend into natural surroundings and cause minimal disturbance makes them ideal for environmental monitoring and data collection. As the technology matures, the next generation of drones is set to become an indispensable tool in advancing scientific research and expanding the capabilities of various industries.

- Fast ground-to-air transition with avian-inspired multifunctional legs (nature.com)
- The Future of Drones: Trends and Innovations in 2024 (edrones.review)
- The Future of Military Drones: Innovations and Strategic Implications (totalmilitaryinsights.com)
- Citizen visions of drone uses and impacts in 2057: Far-future insights for policy decision-makers (sciencedirect.com)

3.10.4 Artificial reefs

Artificial reefs are human-created freshwater or marine benthic structures. They can be built for a variety of reasons, including controlling erosion and protecting coastal areas, blocking ship passages, blocking the use of trawling nets, supporting reef restoration, improving aquaculture, or enhancing scuba diving and surfing. The dream of rescuing coral reefs is not new, and promising innovations in building artificial reefs continue to emerge. For instance, researchers are developing 3D-printed coral structures using materials like biodegradable plastics and concrete mixtures that encourage coral growth and support diverse marine life. Another innovative approach involves "reef balls" made from specially designed concrete that mimics natural reef structures, improving habitat complexity and stability. Additionally, scientists are exploring the use of bioengineered materials that release nutrients or provide favourable conditions for coral larvae's settlement, potentially accelerating reef recovery. Another approach is reef replica made from sustainable cement that can mimic the wave-buffering effects of natural reefs and provide pockets for marine life whilst minimising material use. These advancements aim to address reef degradation by creating resilient, sustainable habitats that support marine biodiversity and ecological balance.

- Artificial reefs built by 3D printing: Systematisation in the design, material selection and fabrication (sciencedirect.com)
- Designed and restored reefs & aquatic ecosystems (Reefballfoundation.org)
- Density of coral larvae can influence settlement, post-settlement colony abundance and coral cover in larval restoration (pmc.ncbi.nlm.nih.gov)
- Artificial reef designed by MIT engineers could protect marine life, reduce storm damage (sciencedaily.com)

3.11 Emerging issue 11: Europe's dual challenge: Demographic shifts and their effects on the future of work

The median age in all countries around the globe is increasing, but at different rates and from a different starting position. This demographic change is causing some countries' social systems to break down and a lack of workers in critical areas, whereas other countries face skyrocketing un- and under-employment, weakening economies from emigrating citizens, and strain on social safety nets. Europe is grappling with the dual challenge of an ageing population and declining birth rates, prompting concerns about who will provide care for the elderly, who are traditionally shouldered by families but increasingly reliant on formal caregiving services due to changing societal dynamics. This shift poses economic challenges, straining public budgets and healthcare systems and raising concerns about future tax revenues and workforce sustainability. An ageing workforce presents significant challenges, necessitating innovative solutions to address potential knowledge and skill shortages as older employees retire.

3.11.1 Aging population and labour shortages might slow down sustainability

Ageing populations in developed countries put increased pressure on healthcare systems and pension funds. This could cause governments to divert resources from sustainability efforts to support these essential social systems, hindering progress toward sustainability transitions. Labour shortages in sectors critical to sustainability, such as renewable energy, nature conservation, and sustainable agriculture, may further slow down these transitions. The demand for workers in these fields is growing, but ageing workforces in developed countries could struggle to meet such demand. Additionally, the need to maintain economic productivity in ageing societies may push governments to focus more on immediate economic stability than long-term environmental goals.

- Working Group on Ageing Populations and Sustainability - European Union (europa.eu)
- New challenges and opportunities in retirement (europa.eu)
- Tailoring social welfare and energy transition for an aging population | Economic Change and Restructuring (springer.com)

3.11.2 Automation in an age of demographic shifts

In response to an ageing population and labour shortages, advancements in technology, such as automation and the introduction of robotics, are being increasingly adopted. These innovations, including service and care robots equipped with sophisticated sensors and AI, can support pensioners and elderly human workers, boosting productivity and reducing the physical demands on an ageing workforce. Moreover, robots and more automatisations can attract a younger population by taking over unattractive tasks and offering roles that require advanced technical skills. Addressing these issues requires re-evaluating social support systems, economic policies, and sustainability strategies to ensure the planet's well-being and current and future generations.

- Exploring the Power of AI and ML in Smart Grids: Advancements, Applications, and Challenges (frontiersin.org)
- AI may turn the economy into a disaster movie (bloomberg.com)

3.12 Emerging issue 12: Shifts in the food production and supply: New potentially sustainable alternatives

The food system is undergoing significant changes as we seek more sustainable alternatives to traditional food production and supply. Some key shifts include alternative food production methods such as vertical farming, plant-based proteins, and the cultivation of food underwater, modern homesteading - the act or practice of living frugally or self-sufficiently - the utilisation of agricultural byproducts, and emerging urban farming methods.

All these changes may contribute to the targets of the EU's Farm to Fork Strategy, e.g. that at least 25 % of the EU's agricultural land should be farmed using organic processes by 2030. In 2021, the total area used for organic agricultural production within the EU was around 16.0 million hectares. The EU's organic area increased by 6.6 million hectares between 2012 and 2021 (up about 70 %) (Eurostat, 2023).

3.12.1 Can underwater agriculture reshape the future of food?

Aquaculture has long been used to grow and harvest foods from marine and freshwater environments, but more and more companies are now looking at ways to grow traditional crops such as strawberries and herbs under the sea. Nemo's Garden, for example, is a pioneering project in underwater agriculture to cultivate terrestrial plants in transparent and filled-with-air biospheres anchored underwater and offer a controlled environment benefiting plant growth. The Ocean Reef Group, another project, has already yielded everything from tomatoes to courgettes, beans, mushrooms, lettuce, orchids and aloe vera plants using hydroponic techniques.

Another type of underwater farming is seaweed farming, mainly practised in Asia, particularly China, Indonesia, the Philippines, and Japan. Seaweed farming does not require pesticides, fertilisers, land, or freshwater to produce. Seaweed can be used as a building block for plastics, diesel, and fibre. Green Wave, a North American company, has developed a more complex approach. Its vertical underwater farms grow a range of algae, such as kelp and shellfish, including mussels and scallops, on a system of cables under the sea, while the algae absorb CO_2 from the ocean, making the water less acidic and helping wildlife thrive, and shellfish, such as oysters, actually improve water quality. What is unclear is the impact on the environment, e.g. the possible destruction of marine habitats, invasive species or the accumulation of waste.

- Nemos garden (nemosgarden.com)
- What are underwater farms? And how do they work? (weforum.org)
- Underwater Farming: The Future? (environbuzz.com)

3.12.2 Homesteading as an alternative to conventional food production

Modern homesteading gained prominence in both rural and urban areas. The trend is motivated by the desire for a simpler life, healthier and ethical food, less environmental impact, and more control and resilience over food sources. The growing desire for self-sufficiency could have mixed impacts on biodiversity. On one hand, it may help preserve biodiversity compared to agricultural products bought from industrial monocultures. On the other hand, if not well managed, a significant upswing in people trying to live directly off the land could put increased human pressure on natural habitats and wild species.

- Homesteaders-live-off-land (washingtonpost.com)
- Why homesteading is growing trend with millenials (businessinsider.com)
- The latest trends in homesteading: From urban to re-wilding (taimio.medium.com)

3.12.3 The potential of food waste and agricultural (by-)products

Innovations in food waste and agricultural by-products are transforming sustainability practices across industries. For example, food waste is increasingly used to produce bioenergy through anaerobic digestion, producing biogas that can replace fossil fuels. Agricultural residues, such as crop residues, are converted into organic fertilisers that enrich the soil while minimising reliance on synthetic alternatives. Sustainable packaging solutions, such as mycelium-based materials and bioplastics derived from eggshells, convert waste into biodegradable alternatives to plastic, reducing pollution. In addition, surplus food and by-products are up-cycled into new foods and snacks, addressing food waste and food insecurity. Even non-food sectors benefit from agricultural fibres from pineapple leaves and coconut shells used in textiles and building materials. These innovations exemplify the principles of the circular economy, using waste as a resource to improve sustainability and efficiency.

Balancing the different uses of agricultural by-products and food waste, such as bioenergy, organic fertilisers or bioplastics, is crucial to optimising resource use and achieving sustainability goals. This requires careful decision-making to prioritise different uses, considering environmental impacts. However, it is also important to note that not all bioplastics are biodegradable or compostable. In particular, some bioplastics require specific industrial composting conditions to break down effectively. Otherwise, they may not break down properly in the natural environment, leading to pollution. In addition, improper waste management, such as mixing biodegradable plastics with conventional plastics, can hinder recycling processes and contribute to environmental damage, such as plastic contamination in ecosystems.

- Breaking down the process: how to make bioplastic from eggshells? (ecomaniac.org)
- Food waste to food security: transition from bioresources to sustainability (mpdi.com)
- Recycling agricultural wastes and by-products in organic farming: biofertilizer production, yield performance and carbon footprint analysis (mdpi.com)
- Comprehensive analysis of bioplastics: life cycle assessment, waste management, biodiversity impact, and sustainable mitigation strategies (peerj.com)

3.12.4 *The potential and the pitfalls of urban farming*

Urban farming, the practice of cultivating, processing, and distributing food in urban areas and other farming methods often applied in urban areas, such as vertical farming, hydroponics, and rooftop gardens, have gained increasing attention as cities strive to create sustainable and secure food systems.

Urban farming offers several advantages, including reducing food miles, which helps lower the carbon footprint associated with food production and distribution, fosters localised food systems, ensuring fresher produce for city dwellers. Additionally, it provides economic opportunities by creating jobs and supporting entrepreneurship, particularly for small-scale farmers, gardeners, and businesses involved in urban agriculture. Urban farming methods also help to cool cities by mitigating the effects of urban heat islands and supporting biodiversity by providing habitats for insects and birds. Furthermore, urban farming maximises limited space while minimising water and energy consumption.

However, urban farming also presents significant challenges. One of the primary concerns is the potential contamination of crops by pollutants commonly found in urban environments, such as air pollutants, heavy metals, chemicals, and industrial waste. Plants can absorb these contaminants and pose health risks to consumers. Water sustainability is another challenge, as urban areas often face water scarcity. Relying on rainwater or public water supplies for irrigation can strain already limited water resources. Additionally, regulatory obstacles, such as zoning laws and building codes, can limit the expansion of urban agriculture, while the energy requirements of technologies like vertical farms—which rely on artificial lighting and heating—necessitate a sustainable energy supply, often requiring renewable sources to ensure environmental sustainability.

Beyond its environmental and economic contributions, urban farming has valuable social benefits. It promotes social integration by involving local communities in farming activities, fostering stronger relationships and a sense of belonging, which can improve mental health. Participatory urban agriculture has been shown to increase community cohesion and even reduced crime rates by enhancing informal surveillance. Additionally, urban farms provide educational opportunities, teaching children and young adults about nutrition, sustainability, and environmental stewardship. These activities equip future generations with the knowledge to live more sustainably and responsibly. As urban populations grow, urban farming will play an essential role in food security, environmental sustainability, and urban planning. Balancing its potential benefits with the challenges it presents will be crucial for its integration into sustainable urban development

- Scaling up urban agriculture: Research team outlines roadmap (sciencedaily.com)
- Urban farming: the benefits and challenges that come with it (help.synnefa.io)
- Are There Any Disadvantages of Urban Agriculture? (greeninfrastructure.com)
- Perspective: City farming needs monitoring (nature.com)
- Human biomonitoring survey for urban gardeners exposed to metal contaminated soils (sciencedirect.com)

3.13 Emerging issue 13: Water - A ticking time bomb for sustainability

The world is facing a systemic water crisis that is both local and global, with nations and regions connected through the water cycle due to increasing demand, misuse, mismanagement, and continuous pollution of water. Mismanagement of water resources, exacerbated by climate change and biodiversity loss, has thrown the global water cycle out of balance, with potentially catastrophic consequences for human societies and ecosystems.

The Global Commission on the Economics of Water (2023) has published a report warning that by 2030, global demand for freshwater could exceed supply by 40%. The report promotes collective action and a systems-thinking approach to overcome the failures of previous policies, which are considered short-sighted, incremental, and divided.

3.13.1 Illegal water markets

Illegal water markets are emerging in regions lacking water governance, exacerbating the water crisis and contributing to aquifer depletion. In Jordan, for example, informal water markets have been found to supply up to ten times as much groundwater as official government well licenses permit, driving aquifer depletion and impeding the government’s sustainability goals.

– Unexpected growth of an illegal water market (nature.com)

3.13.2 Desalination plants are spreading rapidly

Desalination plants are expanding rapidly worldwide, including in Europe, in response to increasing water scarcity. These plants are designed to provide essential freshwater by removing salt from seawater, but their environmental impacts raise significant concerns. One of the primary concerns is the high energy consumption required for desalination, making it an energy-intensive solution. Additionally, the desalination process produces brine, a highly concentrated salt by-product often discharged into the ocean. The high concentration of salt affects marine life. In addition, the brine can contain concentrated residues of synthetic chemicals and pollutants harmful to marine life.

– The desalination process gives us freshwater – at a huge environmental cost (weforum.org)

3.13.3 Extraction of water by large corporations to the detriment of the local population

The issue of water extraction by large corporations, often at the expense of local communities, is a widespread concern worldwide. In many cases, large companies are granted access to significant water resources, often exceeding local needs and threatening the availability of drinking water for local people. This is often exacerbated by a lack of transparency and accountability in agreements between companies and local authorities. These deals, sometimes kept confidential, allow companies to operate with minimal public scrutiny and circumvent regulations, leading to systemic failures to protect water supplies.

– A prime example of the problems associated with water extraction is Leag, one of Germany's largest coal companies, whose mining operations have caused severe groundwater depletion in Brandenburg, Berlin and Saxony. Despite losing billions of cubic metres of groundwater in some driest regions, local authorities have maintained confidentiality agreements, preventing proper monitoring and accountability. This lack of transparency contrasts with industries such as the Tesla factory, which uses far less water but faces disproportionate scrutiny. Similarly, large-scale avocado plantations in Portugal's Algarve region have raised environmental concerns due to their massive water use, depleting local aquifers and damaging biodiversity. Despite regulatory challenges, these plantations continue to expand, exacerbating local water scarcity without providing significant economic benefits to the community.

- The battle for water: The Leag coal group (correctiv.org)
- New plantation seeks to expand dry Alentejo's thirsty crop of avocados tenfold (portugalresident.com)

3.13.4 Urban water crises are driven by unsustainable consumption, mainly from elites

Urban water crises are becoming a global concern, mainly due to the unsustainable consumption patterns of urban elites. Over 80 metropolitan cities worldwide have faced severe water shortages due to droughts and unsustainable water use. Future projections are alarming, with urban water crises expected to worsen and disproportionately affect the disadvantaged. Social inequalities play a major role, with urban elites overconsuming water while excluding less-privileged populations from basic access.

In Cape Town, for instance, elite and upper-middle-income residents account for more than half of the city's household water usage despite representing a much smaller proportion of the population. These residents often consume far beyond basic needs for amenities such as private gardens, swimming pools, and household luxuries. Meanwhile, poorer residents face severe restrictions, often limited to water for essential needs like cooking and bathing.

- Urban water crises driven by elites' unsustainable consumption (nature.com)

3.13.5 Droughts and the role of soils, even in Europe

According to the EEA (2024), by mid-century, the frequency and intensity of heatwaves and droughts in Europe are projected to increase in most parts, significantly affecting soil and agricultural productivity. These changes, exacerbated by climate change, threaten soil fertility and productivity, particularly in cereal crops. In addition to climate change, conventional agricultural practices aggravate the damage. Intensive farming reduces the diversity of soil biota, further destabilising plant communities during droughts. This biodiversity loss leads to weakened soil structure and reduced resilience against environmental stress.

Dry soils also play a critical role in climate regulation. Decreased soil moisture disrupts carbon and water cycles, directly affecting greenhouse gas emissions. Soils with low moisture hinder microbial activity and mineralisation processes, leading to higher greenhouse gas emissions. These processes are essential to soil's role in regulating climate through biogeochemical cycles. Consequently, the feedback loops arising from these changes elevate the urgency of enhancing soil resilience against extended drought periods.

- The role of soil in regulation of climate (royalsocietypublishing.org)
- Harnessing root-soil-microbiota interactions for drought-resilient cereals (sciencedirect.com)
- Soil Biota Adversely Affect the Resistance and Recovery of Plant Communities Subjected to Drought (springer.com)
- Harnessing soil carbon sequestration to address climate change challenges in agriculture (sciencedirect.com)

3.14 Emerging issue 14: New ways of construction: Lightweight, resource-efficient, climate change resilient

The construction industry is evolving to meet sustainability challenges, increase resource efficiency, and resilience to climate change. Recycled materials from construction and demolition waste are gaining traction as a viable alternative to virgin resources. In addition, new materials are being re-discovered (e.g., mycelium, bamboo, or straw bales) or developed (e.g., geopolymer as an alternative to cement or advanced plastics).

Innovative construction methods are at the forefront of this shift. 3D printing technology (also known as additive manufacturing or additive construction) offers precise, efficient construction processes that minimise material waste and enable using recycled concrete and other sustainable resources.

3.14.1 New or modified materials for construction

In construction, existing materials are being modified in manufacturing processes, and new materials are emerging, such as composites made from earth-abundant elements. Examples of such materials and composites include:

- Engineered timber, such as cross-laminated timber (CLT), is an engineered wood that increases stability. CLT is used in mid- and high-rise buildings as a sustainable alternative to steel and concrete.
- Geopolymer concrete has emerged as a sustainable alternative to cement that can reduce carbon emissions by up to 80%. This material can be designed to withstand extreme temperatures and aggressive environments, making it suitable for climate-adaptive structures.
- Bamboo is fast-growing and highly renewable, making it an abundant resource. Composites enhance bamboo's natural strength and durability and can be used in flooring, wall panels, and structural components.

– The ultimate eco building – made of salt, sunflowers and recycled urine (the guardian.com)
– Recycled waste glass can help solve sand shortages (downtoearth.org)
– Geopolymer Concrete: A Sustainable Alternative to Portland Cement (azobuild.com)
– Mechanical Behaviour of Bamboo, and Its Biomimetic Composites and Structural Members: A Systematic Review (springer.com)

3.14.2 New construction methods and concepts

Examples of the latest construction methods and concepts, which increasingly focus on being lightweight, resource-efficient, and climate change resilient, are:

- 3D printing of buildings: 3D printing enables the creation of complex designs that can withstand extreme weather conditions, such as curved walls for improved aerodynamics in high-wind areas, allows the use of both, fewer and more environmentally friendly materials, and saves on transport.

- Biomimetic architecture: a multi-disciplinary scientific approach to sustainable design that goes beyond using nature to merely inspire aesthetics onto deeply studying and applying construction principles found in natural environments and used by species.
- Smart adaptive building envelopes: the building envelope refers to the fundamental components on the exterior of a building that are responsible for environmental isolation and load-bearing. A smart building envelope retains the traditional functions of a building envelope - thermal insulation, wind protection, waterproofing, and structural support - while also autonomously adjusting to environmental changes, achieving a comfortable indoor environment and efficient energy utilisation.
  - A review of 3d printing technology-the future of sustainable construction (sciencedirect.com)
  - What is Biomimetic Architecture? (archdaily.com)
  - Advancements in smart building envelopes: A comprehensive review (sciencedirect.com)

3.14.3 Growing need for sustainable cooling solutions

The energy renovation of buildings can improve their resilience against heat and reduce the energy used for cooling. The increase in vulnerability and exposure to heat is a concern in all European countries and can occur even in well-insulated, newly constructed or renovated buildings. With rising temperatures and longer heat-waves, a growing demand for cooling solutions such as air conditioning poses significant environmental challenges. Air conditioners consume large amounts of electricity and often use refrigerant gases with a high global warming potential. In the EU, refrigerants are responsible for around 2.5% of greenhouse gas emissions. Alternatives such as propane are less harmful but are not widely used in air conditioning systems. This highlights the urgent need for sustainable cooling solutions to mitigate the environmental impact of increased air conditioning use and to address climate change.

- How to Stay Cool Without Warming the Planet - The race is on to create climate-friendly air-con technology (wired.com)
- Cooling buildings sustainably in Europe: exploring the links between climate change mitigation and adaptation, and their social impacts — European Environment Agency (europa.eu)

4 Conclusions

From the more than 800 pieces of information collected using the four work areas of the EEA-Eionet Strategy 2021-2030 as a starting point, 150 weak signals were identified and grouped into 48 emerging issue clusters, of which 14 emerging issues were subsequently elaborated. Each emerging issue is underpinned by developments or weak signals in the ecological, technological, economic, political and/or social fields. This selection is by no means exhaustive and does not (and cannot) represent all developments linked to the topic. The signals identified reflect relatively new phenomena that may evolve or disappear over time. Equally, other relevant signals from an environmental perspective may emerge quickly.

From a cross-cutting perspective, this year's horizon scanning process has identified several emerging trends that merit attention. These global trends are particularly relevant to European environment and sustainability policies.

- **The world is changing faster than expected,** driven by increasing conflicts and geopolitical shifts. Europe is directly or indirectly involved in wars, with serious consequences for the environment and human health. In addition, the global order is increasingly uncertain - for example, over the future role of the US, China, Russia and other global powers - and could shift global political priorities away from environmental issues and multilateralism. The challenge for European environmental policy is understanding the broader implications of these diverse developments. Thus, an important question is how governance institutions (at the EU and national level) can adapt and deploy anticipatory policies to help navigate such complex and interconnected sustainability challenges.
- **Nature is changing faster and more unpredictably**, driven not only by climate change and biodiversity loss but also by emerging issues such as changing water flows, technological changes such as the increasing use of genetic engineering or lab-grown futures, and the uncontrolled spread of microplastics and chemicals. These developments may result in the irreversible loss of natural assets, the redefinition of bioregions, and the rise of human-engineered landscapes and organisms and require policymakers to be open to change, forward-looking and prepared to deal with unforeseen consequences. Recognising and embracing uncertainty in environmental change is crucial for responsive and adaptive policies.
- **The future of the European economy and Green Deal is uncertain** due to growing economic uncertainties, new priorities and changes, for example, in the political landscape after the many elections held in 2024 and in global innovation and competitive landscapes, e.g. due to the 'subsidy war' between the US and China. A shared understanding of what Europe's economic future should look like and what role the environment and sustainability will play in it is just as important as anticipating potential economic disruptions and their impact on environmental policy. Therefore, environmental policymakers should already be developing strategies to successfully manage sustainability transitions during times of economic downturn.

- **A change in social consciousness is urgently needed**, especially in an increasingly polarised and unstable society. Growing social discontent, the emergence of cultural conflicts over issues such as diversity and minority rights, and the increasing psychological stress caused by ongoing environmental and climate crises are deepening divisions and highlighting the importance of the way we communicate. For example, what new technological communication channels, formats and tools could be used? What insights can be drawn from psychology, neuroscience or marketing that could improve the reception of communication by the respective target groups? What innovative ways are there to improve the communication skills of administrative staff and political personnel?

The 14 emerging issues identified and the corresponding signals for each emerging issue are not only interesting from an environmental and sustainability policy perspective. They are also relevant from the perspective of the four work areas of the EEA-Eionet Strategy 2021-2030, as shown in Figure 5:

- Biodiversity and ecosystems
- Climate change mitigation and adaptation
- Human health and the environment
- Circular economy and resource use
- Sustainability trends, prospects, and responses

Figure 5: Overview of the 14 emerging issues and weak signals and their relevance to EEA work areas

	Biodiversity	Climate Change	Human Health	Circular Economy	Sustainability
01 Global shifts and their effects on sustainability transitions					
De-risking and re-industrialisation: Europe's response to global disruptions	●	●	●	●	●
The global war of subsidies in the green transition	●	●	●	●	●
Growing polarisation of climate change and environmental discourses	●	●	●	●	●
02 AI: Promises and perils for sustainability					
AI in recycling and waste management	○	○	○	●	●
Using AI to safeguard biodiversity	●	○	○	○	●
AI's thirst for energy, water, and critical raw materials	●	●	○	●	●
Sustainable AI – yet another technology reinforcing a non-sustainable world?	○	○	○	○	●
03 Environmental communication: Integrating the full range of approaches					
Beyond linear narratives	●	●	●	●	●
Psychology and neuroscience for environmental communication	●	●	●	●	●
Awareness through intelligent digital visualisation	●	●	●	●	●
Local storytelling for environment information gaps	●	●	●	●	●
04 From seabed to space: Tapping into untouched resources					
Increasing spotlight on deep sea mining	●	●	○	●	●
Rise of the human efforts in space	●	●	●	●	●
Space debris - risks and consequences	○	●	○	●	●
05 Mental & emotional exhaustion: Environmental & socio-economic stressors affecting well-being					
Eco-anxiety and climate-related distress	○	●	●	○	●
Destruction of cultural heritage and community identity	○	○	●	○	●
Digital overload and information fatigue	○	○	●	○	●
Air pollution may cause cognitive decline	●	○	●	○	●
06 A synthetic world - from plastics to persistent chemicals					
Plastics in the air may change weather patterns	●	●	●	●	●
PFAS: 'The precautionary principle has failed'	●	○	●	●	●
Toxic materials resulting from plastic recycling processes	●	○	●	●	●
07 Hidden emissions: The direct and indirect impacts of armed conflicts					
Monitoring and attribution of military emissions	○	●	●	○	●
AI-driven evolution of warfare	○	●	●	○	●
Rising sales and profits in the global defence industry	●	●	●	●	●

	Biodiversity	Climate Change	Human Health	Circular Economy	Sustainability
08 Out of sync with nature					
New methods to control invasive species	●	○	●	○	●
Engineering plants in response to climate change	●	●	●	○	●
Need for inclusive approaches to biodiversity conservation	●	○	○	○	●
09 Social polarisation – New dynamics with impact on environmental policy					
Growing polarisation on environmental issues and values	●	●	●	●	●
Digital technologies: advancing progress or exacerbating inequality?	●	●	●	●	●
10 Human Hubris – The rise of techno-biological engineering					
Synthetic biology on the rise	●	●	●	○	●
Desperate nations may unilaterally begin geoengineering the global climate	○	●	●	●	●
Next generation of drones	●	○	●	●	●
Artificial reefs	●	●	○	○	●
11 Europe's dual challenge: Demographic shifts & their effects on the future of work					
Aging population and labour shortages might slow down sustainability	●	●	●	●	●
Automation in an age of demographic shifts	●	●	●	●	●
12 Shifts in the food production & supply: New potentially sustainable alternatives					
Can underwater agriculture reshape the future of food?	●	●	●	○	●
Homesteading as alternative to conventional food production	●	●	●	○	●
The potential of food waste and agricultural (by-)products	●	●	○	●	●
The potential and the pitfalls of urban farming	●	●	●	●	●
13 Water: A ticking time bomb for sustainability					
Illegal water markets	●	●	○	○	●
Desalination plants are spreading rapidly	●	●	●	●	●
Extraction of water by large corporations to the detriment of the local population	●	●	●	○	●
Urban water crises driven by unsustainable consumption	●	●	●	○	●
Droughts and the role of soils, even in Europe	●	●	●	○	●
14 New ways of construction: Lightweight, resource-efficient, climate change resilient					
New or modified materials for construction	●	●	●	●	●
New construction methods and concepts	○	○	○	●	●
Growing need for sustainable cooling solutions	○	●	●	○	●

Source: Own representation and assessment

The following section highlights those emerging issues of particular relevance to all work areas which require holistic policy responses:

- **Artificial intelligence** is a cross-cutting topic that simultaneously presents opportunities and poses issues for the environment. Many emerging AI-driven environmental applications, such as those for the preservation of biodiversity or waste management processes, offer opportunities to promote environmental sustainability. On the other hand, the massive increase in energy and resource requirements expected in the future due to AI is likely to have a major impact on the climate and the environment.
- The impacts of **climate change** are still largely underestimated. This is the case in many domains, and **water** is one. The world is facing a systemic water crisis due to increasing demand, mismanagement and environmental pollution. Compounded by climate change, this poses potentially catastrophic consequences for human societies and ecosystems.
- Growing **ecological and climate anxiety**, the psychological impact of pollution, and the erosion of cultural heritage and community identity have profound emotional and mental health consequences. These issues call for professional management of environmental policy and initiatives that foster a sense of connection with nature, community, and agency.
- A plethora of new technologies—synthetic biology, genetically modified climate-resilient plants, and geoengineering—are emerging in an attempt to **re-engineer nature.** These innovations promise to restore biodiversity, combat climate change, overcome food and water shortages, fight disease, and more. However, these innovations pose challenges, including potential health risks from synthetic substances, unforeseen impacts on ecosystems, and ethical questions about genetic engineering. As these technologies evolve, vigilance and regulation are needed to minimise unintended consequences.
- Novel forms of **environmental communication**, such as those informed by neuroscience, psychology, virtual reality, and storytelling approaches, can play a key role in raising public awareness of complex environmental issues and in inspiring action for sustainability.

These insights help to identify research and policy gaps, develop targeted national and European recommendations, and strengthen cooperation. Sharing practical experiences through webinars, expert discussions, and collaborative activities can further align national and European efforts, enhancing the overall impact of environmental policy and research.

5 List of abbreviations

Abbreviation	Name	Reference
AI	Artificial intelligence	
EEA	European Environment Agency	www.eea.europa.eu
Eionet	European Environment Information and Observation Network	https://www.eionet.europa.eu/
ETC ST	European Topic Centre on Sustainability Transitions	https://www.eionet.europa.eu/etcs/etc-st
FSC	Foresight Strategy Cockpit	https://www.4strat.de/foresight-strategy-cockpit/
SOER	The European environment — state and outlook	https://www.eea.europa.eu/soer
STEEP	Social-Technological-Environmental-Economic-Political categories	https://foresightguide.com/horizon-scanning-frameworks/

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https://www.eionet.europa.eu/etcs/etc-st

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