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Emerging issues of policy relevance for land use and circular economy

Insights from the Eionet Participatory Horizon Scanning Pilot 2022

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Description

The eight emerging issues identified through the participatory Eionet horizon scanning pilot 2022 illustrate that there are novel developments and neglected views that could gain in importance in the context of sustainability transitions for land use and for the circular economy.

These emerging issues open a panoply of innovation opportunities that could accelerate sustainability transitions in the fields of land use and circular economy by co-development of previously separated policy fields.

The reframing of environmental issues is likely to irritate some readers at first sight. Acknowledging changes in the human-nature relationship, integrating peripheral perspectives in land use policy, contrasting the ambitions of the circular economy to its reality and the re-embedding of the circular economy into a changing, yet uncertain geopolitical context, all challenge our incumbent ways of thinking about land use and the circular economy. This is exactly what horizon scanning is about: the identification of emerging issues to stimulate thinking about anticipatory governance approaches.

Executive summary

Horizon scanning is a systematic process encompassing the identification of weak signals of emerging trends, events and issues of policy relevance. Emerging environmental issues are phenomena that are completely new, which are known but new to environmental policymakers, or known but controversial or uncertain, including changes to the understanding, exposure or perception of an issue. Horizon scanning enables policymakers to gain new insights about future developments and make strategic decisions that strengthen the resilience of current policies to future shocks and uncertainty.

In March 2022, the European Environment Agency and the European Topic Centre for Sustainability Transitions (ETC ST) initiated a participatory horizon scanning process involving the Eionet Groups (EGs) on Foresight and State of the Environment (SoE). One of the aims of the exercise was to identify and briefly characterise a set of emerging issues of relevance to the environment around a topic or topics of relevance to the Eionet countries. The topics selected by the participants were land use and the circular economy.

This report presents the characterisation of eight emerging issues, four on land use and four on the circular economy. It aims to plant seeds and trigger curiosity around the risks and opportunities these issues may pose to the environment and environmental policy at the EU and at the country level. Depending on their nature, the emerging issues differ considerably in the availability of empirical data, knowledge of environmental impacts, and how uncertain their development is. What they have in common is that they all bear novel aspects and have environmental relevance.

The four emerging issues for land use are:

Agrivoltaics and portable wind turbines– multi-purpose and flexible land use in view of the energy transition

Small-scale and decentralised innovations for renewable power generation are emerging that represent the design principle of multiple purposes (e.g. agrivoltaics) and of flexible seasonal area usage (e.g. portable wind turbines) in novel ways. Agrivoltaics and portable wind turbines spread over rural areas and even knock at the doors of protected areas.

Multi-purpose and seasonal area usage solutions have the potential to play a significant role in the acceleration of the energy transition if they could be scaled up quickly. The land use efficiency potential and limitations of the myriads of 'multi-purpose and flexible land use renewables' need to be compared to those of the few 'centralised large-scale solutions'. In particular, the induction of power demand in rural and remote areas and land use efficiency rebound effects are emerging issues of relevance to environmental policy.

Rethinking the human-nature relationship – from novel perceptions to the 'Rights of Nature'

A nature-centric approach called 'ecosystem flourishing' is emerging which attributes an own value to plants, animals and ecosystems disregarding their usefulness for humans. What if trees are seen as inhabitants of cities with a vital stake in sufficient space? What if we have to negotiate with rivers before using them for human purposes?

If the human-nature relationship increasingly accounts for multi-species communication and the rights of nature are reinforced, land will no longer be perceived as passive, silent and fragile but it will be an active holder of rights. While biodiversity will flourish on most territories, the human-nature relationship would be challenged by vague delineations and conflicts over the natural and the anthropogenic in hybrid spaces such as green infrastructure and limit the exploitation of nature for the bioeconomy.

Novel food and feed from the oceans – food without land

The idea of cultivation and extraction of protein-rich food and feed from the oceans has gained momentum to reduce livestock keeping alleviating pressure on land use and curb carbon emissions. While seaweed is a common staple in East Asian countries, the EU strives to accelerate the development of a European algae industry and to promote algae for culinary and other uses.

If ocean value chains were established for all relevant products and scaled up, there could be increasing competition between the ocean uses for food, carbon storage, energy and other purposes. On a global scale, the exploitation rights of the seafloor may need to be revised. If the attention moves to the oceans, countries that have direct access to oceans will be privileged over landlocked countries. At the same time, the diverse impacts of wild seaweed harvesting and of underwater farming on biogeochemical cycles and biodiversity are not well understood.

Peripheral perspectives on land use – towards the acknowledgement of diverse practices and culture in land use management

Unresolved land use issues have prompted the search for new and peripheral perspectives, including visions for rural areas from within, land use in Europe from a non-Western perspective, informal land use, common land tenure, and learning from land use governance abroad (e.g. South America, India). Research on the causal role of culture in land use has been limited, too.

With the emergence of participatory tools in land use planning, new and peripheral perspectives and diverse land use cultures can be taken into account more easily. While there is a potential that more locally adapted land use patterns will be beneficial to the environment (e.g., permaculture with multiple synergetic outputs), the upscaling of sustainable solutions (e.g., for biodiversity) could be slowed down due to the local variations in perspectives and culture.

The four emerging issues for the circular economy are:

Energy transition amidst an energy crisis – a window of opportunity for a circular energy transition?

The Russian attack on Ukraine has shaken energy markets. As a result, oil and gas prices rose to their highest levels in almost a decade, forcing many countries to rethink their energy supply. Many governments took immediate action to address the energy crisis. The circular economy is often ignored in current political activities related to the energy transition.
As the pressure is very high to find solutions to the energy crisis, this could be a window of opportunity to bring the circular economy issue to the forefront. The vulnerability of supply chains, for example, could offer an opportunity to shift to more localised energy production systems and keep raw materials in the loop. With rising prices and inflation, the financial pressure on citizens increases, which could lead to more energy efficiency, sufficiency, longevity of products, etc., thus strengthening a circular energy system.

The reality of circularity – upcoming challenges to prevailing circular economy concepts and mindsets

According to the Circularity Gap Report 2022, our world is only 8.6% circular, which leaves a massive circularity gap of over 90%. Even, if there is still a long way to go, the vision of a circular economy is becoming more and more popular. Many countries across the world have made the transition to a circular economy one of their policy priorities.

But there are also other voices that doubt that a circular economy can be achieved at all, because energy is always required to maintain pure materials, the production of renewable energy has always an ecological footprint and many other reasons. Therefore, many call for bringing more realism into the debate, for instance, by

- recognising the limits of the circular economy
- shaping concepts and definitions acknowledging physical/natural limitations
- promoting a holistic understanding and more system thinking

This would increase the credibility of the circular economy as a vision towards which activities can be directed and help to develop the right strategies for action.

Rethinking bio-based materials – innovations are needed?

Shoes made not from animal leather but from mycelium fibres, car tyres 100% made from dandelion-based natural rubber instead of petroleum-based polymers, or carbon fibres in aeroplanes made of algae - in times of raw materials scarcity and increasing environmental pressures, bio-based materials promise a sustainable alternative to fossil-based alternatives. In recent years, the range of plants for the production of bio-based materials and their areas of application have steadily expanded. Biomaterials enable novel product properties such as reacting on external conditions, repairing themselves or extinguishing themselves. However, innovative biomaterials are accompanied by environmental challenges: Some bio-based materials may be more sustainable than others along the entire value chain. The more the demand for food, feed, biomaterials and bioenergy resources increases, the more this could lead to intensified pressure on natural resources, for instance, on land use.
Circularity can help to reduce that pressure, for instance, by keeping biomaterials as long as possible in the loop, and by designing them as biodegradable. To ensure that biobased materials are truly sustainable, there is a need to reconsider priorities and think holistically, e.g., is a given biomaterial really needed (sufficiency)?

Geopolitics & the circular economy – framework conditions in turmoil

The world order as we know it is in a period of upheaval. Putin's Russia attacked Ukraine on February 24, 2022, triggering a war in Europe that is still ongoing. China, under its leader Xi Jinping, is becoming increasingly authoritarian, claiming democratically governed Taiwan as its own territory and increasing its military pressure. In early 2022, China and Russia formed an "alliance of autocracies" and intensified economic trade. Whether the United States can live up to its role as leader of the Western world is unclear because of domestic instabilities such as the increasing radicalization of large segments of the population. The EU is caught between two stools, searching for its role in the world. Russia's military aggression against Ukraine is leading to massive social and economic impacts, particularly food and energy shortages, supply chain disruption, and migration.

It is not clear how the future will look like, and it is difficult to assess the precise consequences for environmental policy in Europe, or the circular economy more concretely. One risk could be, for instance, that governments are under so much pressure to act quickly during disasters or pandemics that they pay little attention to aspects around the circular economy. On the other hand, establishing resilient structures could constitute a window of opportunity for circular economy solutions.

The outputs of this participatory horizon scanning exercise (i.e. weak signal dossiers, candidate theme reports and this emerging issue report1) could serve as a knowledge base for communication activities, further research, and to stimulate policy preparedness. Moreover, the process itself can contribute to strengthen the collaboration within and amongst the Eionet Groups on Foresight and SoE, other Eionet Groups and other actors.

[1] Available on the Eionet Forum: https://forum.eionet.europa.eu/eionet-foresight-group/library/horizon-scanning/2022/outputs

1 Introduction

Europe's state of the environment and environmental policies are influenced by developments of societal, technological, economic, environmental and political nature. Such 'drivers of change' have different origins, natures, stabilities, significances, geographical scales and timescales. Although some of them are well investigated and perceived, some are just emerging, and their effects have not yet unfolded or are still unknown. This is where horizon scanning comes into play: horizon scanning is a systematic process encompassing the identification of weak signals of emerging trends, events and issues of policy relevance (EEA, 2023).

In March 2022, the European Environment Agency and the European Topic Centre for Sustainability Transitions (ETC ST) initiated a participatory horizon-scanning process involving the Eionet groups (EGs) on Foresight and State of the Environment (SoE).[2] The overarching aim was to run a pilot exercise to simultaneously:

- build foresight capacity within the EGs on Foresight and SoE,
- foster the engagement of network members and promote mutual learning – within and across Eionet Groups, the EEA and the ETC ST,
- identify and briefly characterise a set of emerging issues of relevance to the environment around topics of interest to the countries, and to
- explore the value of establishing a regular participatory process of horizon scanning to identify emerging environmental issues relevant to the Eionet[3].

This report documents the set of emerging issues identified in the pilot[4]. It aims to plant seeds and trigger curiosity around the risks and opportunities these issues may pose to the environment and environmental policy at the EU and at the country level.

The participants in the horizon scanning exercise voted to apply the horizon scan to two different topics: land use and the circular economy[5]. In a series of four workshops, supported by various interim elaborations and sense-making activities, a broad variety of weak signals was uncovered in scanning the horizon (60 for land use, 40 for the circular economy). These weak signals[6] were clustered into themes

[2] Task 3.3.2 of the Action Plan 2022 of the European Topic Centre for Sustainability Transitions.
[3] The evaluation exercise undertaken by the ETC ST team is covered in a separate report.
[4] A separate evaluation report reflects on the process and on the possible uses of the horizon scanning outputs.
[5] The methodology used is described in detail in Annex 1 and all the outputs (i.e. weak signals, candidate themes and emerging issues) are available on the Eionet Forum.
[6] Annex 2 lists the weak signals that contributed to the eight emerging issues.

(eight for land use, seven for the circular economy)[7]. Subsequently, participants prioritised four themes per topic to be further elaborated into full emerging issue profiles[8].

The eight emerging issues, four for land use and four for the circular economy, are presented below.

1.1 Land use:

- Agrivoltaics and portable wind turbines– multi-purpose and flexible land use in view of the energy transition
- Rethinking the human-nature relationship – from novel perceptions to the 'Rights of Nature'
- Novel food and feed from the oceans – food without land
- Peripheral perspectives on land use – towards the acknowledgement of diverse practices and culture in land use management

1.2 The circular economy:

- Energy transition amidst an energy crisis – a window of opportunity for a circular energy transition?
- The reality of circularity – upcoming challenges to prevailing circular economy concepts and mindsets
- Rethinking bio-based materials – innovations are needed?
- Geopolitics & the circular economy – circular economy framework conditions in turmoil

A compilation of ideas provided by workshop participants on potential uses of the outputs of the horizon scanning exercise, including the eight emerging issues described in this report, is presented in Annex 4.

[7] Those themes that have not been elaborated into fully-fledged emerging issue profiles are presented in Annex 3.

2 Emerging issues

Emerging environmental issues are phenomena that are completely new, which are known but new to environmental policymakers, or known but controversial or uncertain, including changes to the understanding, exposure or perception of an issue (White et al., 2017).

In this chapter, four emerging issues for land use and four emerging issues for the circular economy are presented. The characterisation of the emerging issues is structured according to the following sections:

- Description (what is it about?)
- Facts and figures (what is going on? what is new?)
- Implications (why does it matter for the future of land use or the circular economy and what are potential implications for environmental policy?)

Depending on their nature, the emerging issues differ considerably in the availability of empirical data, knowledge of environmental impacts, and how uncertain their development is. What they share is that they all bear novel aspects and have environmental relevance, which was ensured in the selection and sense-making steps of the horizon scan (see Annex 1 for the methodology).

2.1 Land use

2.1.1 Agrivoltaics and portable wind turbines– multi-purpose and flexible land use in view of the energy transition

Description (What is it about?)

The transition towards renewable energy is driven by the goal to decarbonise Europe by 2050 and the REPowerEU plan dealing with the energy market issues caused by Russia's invasion of Ukraine (EC, 2022). In most EU Member States, the most suitable sites for renewable energy have already been developed. Yet, the large-scale renewable energy deployment continues and reaches out to new frontiers (for example offshore wind energy parks).

At the same time, small-scale key innovations for renewable power generation are emerging that represent the design principle of multiple purposes (e.g. agrivoltaics) and of flexible seasonal area usage (e.g. portable wind turbines) in novel ways:

- Agrivoltaics denote a collocated agriculture and photovoltaic (PV) infrastructure (Klenske, 2022). Shading by PV panels reduces plants' drought stress and irrigation demand, while the vicinity of plants reduces PV panels' heat stress thus increasing their lifespan. The growing conditions for several crops could be improved and, at the same time, photovoltaics could be scaled up in vast agricultural areas.
- Portable wind turbines attain a power of typically up to 10 kW_p or 100 kW_p. Their size ranges from virtually portable to moveable by a small truck or SUV. The entire small-scale wind turbine market is currently dominated by stationary uses. Portable ones can be shipped to make use of actual local wind conditions (Market Research Future, 2020).

This profile explores the dynamics and implications of agrivoltaics and of portable wind turbines.

Facts and figures (What is going on? What is new?)

Such small-scale, decentralised solutions as agrivoltaics and portable wind turbines particularly spread over rural areas and even knock at the doors of protected areas.

Agrivoltaics:

Agrivoltaics are estimated to increase land use efficiency by 60 % (Trommsdorf, 2022).

Market dynamics and potentials:

- Globally installed agrivoltaics capacity has risen from approx. 3 MW_p to almost 14 GW_p between 2012 and 2021 (Trommsdorf, 2022).
- The technical potential in Germany is approximately 1.7 TW_p (Trommsdorf, 2022).
- The EU could meet 25 % of its current electricity consumption (700 GW_p capacity) if agrivoltaics are deployed on 1 % of arable land (Intersolar Europe, 2021).

Portable wind turbines[9]:

Portable wind turbines can be designed to convert wind energy into power at low wind speeds, typically ranging from 3-10 meters per second, which could help to exploit more sites for wind power generation flexibly (Nabavi and Zhang, 2016).

Market dynamics and potentials:

- In the USA, more than 81,000 wind turbines are used in distributed applications, where the energy is produced at the point of consumption, amounting to a capacity of more than 1 GW_p (PNNL, 2019).
- The global small-scale wind power market is estimated to grow with a CAGR of 13.5 % (2021-2030), Europe being the dominant region (Market Research Future, 2020).

Implications (Why does it matter to land use and environmental policy?)

If agrivoltaics and portable wind turbines become mainstream, this could have significant implications for land use and environmental policy. Moreover, one could imagine photovoltaics being deployed everywhere shade is needed.

The potential and limitations of the myriads of 'multi-purpose and flexible land use renewables' need to be compared to those of 'centralised large-scale solutions'. The actors involved, for example, might differ substantially, from single renewable energy prosumers (EEA, 2022) to large trade-oriented actors. Policy development should consider both paradigms and their respective systemic impacts on land use and other side effects (e.g., of agrivoltaics on crop yields, of mobile wind turbines on species in protected areas). The upscaling of agrivoltaics needs to be in alignment with energy, agricultural and food policies, whereas the upscaling of portable wind turbines needs to be in alignment with nature and landscape protection policies. Natural habitat regulations could, for example, provide exemptions for agrivoltaics and portable

[9] There is no up-to-date data on the portable wind turbine market size available free of cost.

wind turbines. The inherent limitations of both approaches (e.g. not all plants profit from shade, there is an energy trade-off between the movement of wind turbines and the harvesting of wind energy) need to be assessed. Similarly, rebound effects such as the induction of power demand in rural areas and land use efficiency rebound effects need to be considered.

Multi-purpose and seasonal area usage solutions have the potential to play a significant role in the acceleration of the energy transition if they could be scaled up quickly. However, in the case of accidents, such as fire, pollutants may be released into the environment. Also, these appliances being installed in large numbers over the land (dissipative use) contain critical raw materials and pollutants that will be difficult to be fed back into the circular economy, once they go out of use. The "do not significant harm" principle (EC, 2021) could be applied to develop appropriate prevention criteria. The countless decentralised small-scale solutions may have significant adverse effects on the migration of species of terrestrial predators, birds and fish, and thus also on biodiversity.

Like portable wind turbines, agrivoltaics need to be designed flexibly to adjust solar radiation influx to seasonal needs and to extreme weather events (e.g. by selective transparency and absorption of the light spectrum, removable photovoltaics). Agrivoltaic land use has repercussions on agricultural machinery. There could be smaller and more flexible machinery reducing soil compaction, but the capital-intensive exchange of the machinery park could benefit rather large companies than small and medium-sized enterprises (SMEs). Moreover, agrivoltaics might limit the diversity of crops. Agrivoltaics will change the deposition patterns of air-borne pollutants and precipitation run-off conditions which could cause new layouts of agricultural land. Large-scale deployment of agrivoltaics would definitely change the aesthetics of rural landscapes, which would maybe be perceived belonging rather to the technosphere than to nature and look uniform.

Policy design needs to explore whether decentralised small-scale solutions are either used off-grid (e.g., small- or medium scale self-sufficiency) and induce additional power demand (e.g., electrification of farms, pop-up events with mobile wind turbines, etc.), or whether they are connected to the power grid requiring electricity transportation infrastructure. Economic incentives in place tend to support revenue generation with power production rather than energy efficiency and sufficiency.

2.1.2 Rethinking the human-nature relationship – from novel perceptions to the 'Rights of Nature'

Description (What is it about?)

How we perceive and view nature influences how we behave towards it. While intuitive direct communication with nature has become marginal for most Europeans, visual pictures of nature and how we speak about it widely influence our perceptions. Soundscapes (Centre for Global Soundscapes, 2022), smellscapes and alternative lingual and narrative conceptions of nature enrich the ways in which landscapes and ecosystems are perceived. At the same time, digitisation increasingly mediates the perception of nature thereby changing our relations to spaces and places, as more and more people lose their place attachment. Disasters such as extreme weather events question our settlement patterns and are about to re-shape land use policies.

Nature as something external to humans asks for the protection and restoration of ecosystems, as it has been done by EU environmental policies for decades. Acknowledging our various dynamic relationships with nature, still from an anthropogenic perspective, is the predominant paradigm shaping current sustainability research and transitions. An emerging nature-centric approach can be distinguished from these two anthropogenic approaches, which attributes an own value to plants, animals and ecosystems

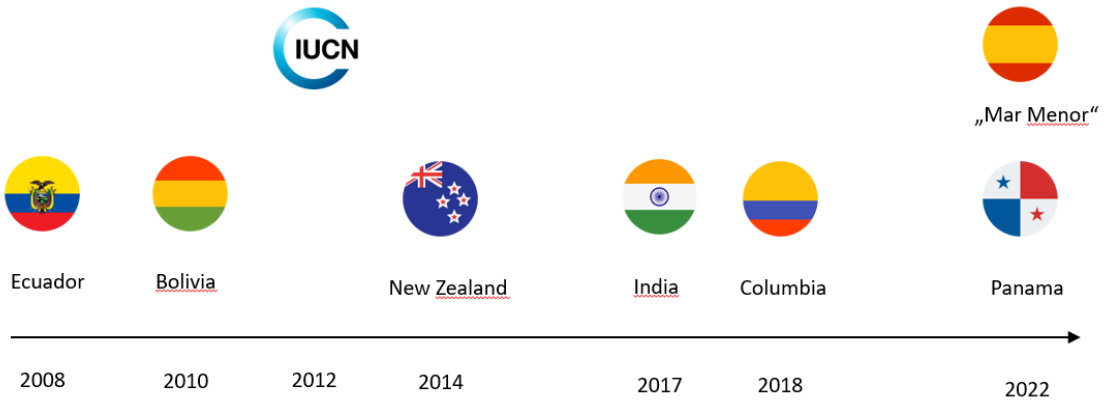
deliberately disregarding their usefulness for humans. This approach may be called 'ecosystem flourishing' (European Commission, Directorate-General for Research and Innovation, Kubeczko, K., Bernstein, M., Wasserbacher, D., Wepner, B. et al., 2023). This profile explores how a strong focus on ecosystem flourishing could change the current thinking about land use and related environmental impacts.

While there is longstanding discussion on different land use conflicts from the human perspective (namely conflicts between the single-use of the land, e.g. fuel vs food, recreational vs. industrial land use), exploring the multiple-use (and users) of the land, recognising the perspective of the ecosystems inhabiting these lands brings in novel angles (Warnke and Könnöla, 2023). What if trees are seen as inhabitants of cities with a vital stake in sufficient space? (Dark Matter, 2020a) What if we have to negotiate with more than human inhabitants of these territories such as mountains or rivers before using their "homelands" for human purposes? What does it really mean to share spaces with nature? (Dark Matter, 2020b). Although some see this concept as unsettled and paradoxical, because we humans could not escape from our human perspective, an urgent need for reconnecting with nature is even claimed by such sceptics.

Facts and figures (What is going on? What is new?)

While the emergence of a countermovement to the dominant view of nature and environment can be observed, indicators on how to measure it and quantitative evidence for 'ecosystem flourishing' can hardly be found. What can be traced is the number of countries that have committed themselves to the rights of nature recently (Figure 2.1). The 'Rights of Nature' idea assumes that "nature possesses fundamental rights, just as humans do" (International Rivers et al., 2020).

Figure 2.1 Illustrative compilation of countries and actors that have assigned rights to nature



Source(s): ETC ST based on Surma, 2022; Wandler, 2022; and ICJ, 2022.

Panama has been the last country embracing a legal movement that gives land, trees, rivers, coral reefs and mountains unique legal rights, similar to humans, corporations and governments. Panama joins Ecuador, Bolivia, New Zealand, India and Colombia, among other countries, which have either issued court decisions, enacted laws or amended constitutions recognising the legal rights of nature. In Europe, the Mar Menor in Spain which suffers from pollution is the first case to be put forward in a national parliament.

Transformative change is needed to halt global biodiversity loss and species extinction. The 'Rights of Nature' approach claims to offer such transformative change (International Rivers et al., 2020). Rivers with their entire catchment areas have become a central action field for the Rights of Nature, as they are under

extreme pressure globally: they suffer from over-exploitation, alteration of natural flow regimes and habitats, and pollution.

However, the assignment of rights to nature and to its species is not a straightforward activity. There are few studies which investigate the relationship between humans and other animals. A study for the USA found out, that people tend to love animals the more as they associate them with warmth (Broad, 2021). It is hard to imagine that they will negotiate the stakes of dogs and cats in the same way as they would do it with mice and rats.

If the human-nature relationships increasingly account for multi-species communication and the rights of nature are reinforced, this could have thorough implications for land use and environmental policy.

Implications (Why does it matter to land use and environmental policy?)

The aggravating ecological crisis could slowly force people to seriously engage with nature. In doing so, they would build on elements from indigenous legal thinking about land, for example property as "curation", property as making kin, property as reconciliation, counselling with nature (Dark Matter, 2020b) and others (Warnke and Könnöla, 2023). Utilitarian views, exerting control over nature are replaced by an immersive, animist culture that values species and ecosystem flourishing.

Human and non-human beings might interact in collectives, in which each being's status and ability to realise life is the principal value. Land is no longer perceived as passive, silent and fragile but as an active holder of rights. Within this pluriverse of beings, land use practices are negotiated between plants, animals, humans, ecosystems and the earth's forces for each collective individually, loosely guided by an overarching framework of multi-species justice (Warnke and Könnöla, 2023). Beyond today's advocacy of environmental non-governmental organisations (NGOs), scientists, artists and indigenous people could act as "diplomats" by translating and mediating. Understanding the language of plants, trees and animals on the shared land would become a key competence.

Principally, the recognition of the rights of nature would be beneficial to the flourishing of protected areas and all living beings with an impact on land use. In this world, land use would be an important indicator of the bigger picture.

Protected areas would be established to secure and recognise the value of ecosystem services in the long-term, but the balance of their own value, ecosystem regulation, provision of resources, and aesthetic and touristic use would need to be re-negotiated.

If 30-50 % of land area would be protected to leave room for nature, this would **limit the area for human use** substantially with repercussions on population dynamics, distribution and settlement patterns. Living and economic activities would require much more land use efficiency. There would be land use competition between animals, plants, and humans. A key challenge would be how to distribute land efficiently and justly between humans and nature.

The **human-nature relationship** would be challenged by vague delineations and conflicts over the natural and the anthropogenic in hybrid spaces, such as pollination in agriculture. Provided there are 'Rights of Nature', land ownership and access to land might challenge the present concept of property, because ecosystem services would belong to the ecosystems themselves. More green infrastructure and nature-based solutions would be implemented in the built environment to allow species to flourish there, too. This could pose challenges to time-efficient infrastructure development and adaptivity to changing claims

during use over time. Other area-based conservation measures would have to be established to account for biodiversity outside protected areas. The changing human-nature relationship could significantly limit the use of bio-based materials and slow down decarbonisation, because of complicated negotiations.

Research will have the task to provide evidence for 'ecosystem flourishing', to study and to enable human-animal communication and rewilding programmes, and to establish living labs to explore solutions to 'ecosystem flourishing'. The different laws and relations between nature and humans would need to be identified and reconciled if possible.

Deliberation models for land use would need to enable the participation of all humans and other species of the current and future generations. For example, there could be physical chairs for bird species, trees, parks and other natural and hybrid entities in the municipal town hall during negotiations. Rights would need to be specified and enforced, and conflicts would need to be resolved. If more and more rights are attributed to plants, animals and nature, the question of human advocacy may gain importance. In some countries such as Germany, environmental NGOs already have the right to go to court if they believe that public institutions and private actors do not comply with environmental legislation. As current sustainable development policies focus on human well-being, 'ecosystem flourishing' policies would be disruptive.

2.1.3 Novel food and feed from the oceans – food without land

Description (What is it about?)

A booming aquaculture industry and imports increasingly satisfy European consumers' demand for fish and seafood while catch quotas for commercial fishing in EU waters limit the extent of the EU's self-supply. The idea of harvesting alternative products from the ocean is not new. Already in the 1970s the small crustacean 'krill' was considered to be the protein source of the future, only to be collected from the cold polar waters. Recently, the idea of cultivation and extraction of protein-rich food and feed from the oceans has gained momentum to reduce livestock keeping. Reductions in consumption of meat, dairy and eggs are seen as a major strategy to alleviate pressure on land use and to curb carbon emissions.

A 'blue economy' is emerging that encompasses energy (e.g., offshore wind), resources (e.g., manganese nodules), transportation (e.g., relocation of shipping routes), communication (e.g., subsea data cables) besides fishing and aquaculture. Novel food and feed from the ocean are likely to play an important role, although this still needs to be defined. Oceans could supply up to six times more food and feed than today, including novel algae food and feed, and biotechnological production of proteins and seaweed valorisation (EFSA, 2022). Besides seafood, terrestrial food could be grown in the ocean (ocean crops).

The demand for ocean food and feed is expected to increase due to the declining availability and quality of land-based soils and the perception of seafood as healthy and sustainable. DG MARE aims to 'accelerate the development of a European algae industry and promote algae for culinary and other uses among consumers and businesses in the EU' (EFSA, 2022). Such uses include pharmaceuticals and nutraceuticals, food additives, bio-degradable packaging, cosmetics, biostimulants, biofuels and the valorisation of other ecosystem services (Seaweed for Europe, 2020).

Facts and figures (What is going on? What is new?)

The incorporation of novel foods in European diets, among them seaweed, could reduce global warming potential, water use and land use by over 80% (Mazac et al., 2022).

Market dynamics and potential:

- It is estimated that by farming two per cent of the ocean, enough protein could be provided to feed a world population of 12 billion people (UN, 2020).
- The global seaweed harvest in 2019 was 35.8 million tons. More than 99% of global seaweed culture production takes place in Asia, namely in China and Indonesia, where it is a staple in the diet. Europe produced just 0.8 % of the global production, almost all of this being harvested from wild stocks (FAO, 2022; Taylor, 2022).
- The association North Sea Farmers has almost 100 members including the food manufacturing giant, Unilever, and the energy firm Shell. They hope to dramatically increase Europe's production of farmed seaweed over the next decade (Taylor, 2022).
- The seaweed industry in Europe could have an annual market value of over 9.3 billion Euros in 2030, thereby sourcing 30 % of its seaweed from European waters. In addition to improved diets and health, 115.000 jobs, more than 5 million tons of carbon emission reductions and the absorption of 20.000 tons of nitrogen and 2.000 tons of phosphorous count among the major promises (Seaweed for Europe, 2020).

Implications (Why does it matter to land use and environmental policy?)

Besides contributing to nutrition and food security issues (FAO, 2022), the establishment of value chains for novel food and feed from the ocean could pose new opportunities and risks for the **environment** and have huge repercussions on land use. In the long-term, novel food and feed from the oceans could reduce the need for land-based soils, in particular grassland for cattle, and reduce related greenhouse gas emissions. However, if the seaweed industry was scaled up, it would have to be designed in an energy-efficient and circular way. This could mean increasing competition between the use of the ocean for food, carbon storage, energy and other purposes. The development of the seaweed industry could indirectly pave the way for the exploitation of other ocean resources, such as jellyfish or sand. At the same time reduced pressure on land-based soils due to ocean cropping and seaweed farming might instantly set these areas free for other intensive land uses such as crop farming for biofuels. Policy initiatives would need to balance the diverse uses of the ocean and account for terrestrial side-effects. In the end, **land use** would be exchanged or complemented by **ocean use**.

A regime for the designation and administration of underwater farming areas and for permission to harvest wild seaweed would need to be established. There would be transportation of raw materials from the ocean floor to the surface, and from there to coastal areas. New harbours and coastal infrastructure (factories, buildings, energy, transportation, waste management, etc.) to process the ocean raw materials into food and feed would be developed in areas close to underwater farms thereby colliding with other coastal uses such as leisure, sports and tourism. There would be a need to generally reduce emissions of such maritime operations for the delivery of food and feed from the oceans. There are environmental concerns about large-scale underwater farming and wild seaweed harvesting, in particular in relation to marine and coastal biodiversity and ecosystem health. Farming operations are likely to churn up ocean soil and water. Policies need to consider the '**do no significant harm**' principle and develop red lists of habitats and endangered species to avoid and mitigate adverse impacts of seaweed production on biodiversity.

There is a need to develop **holistic policies** to ensure consistency between the various existing policies on food, energy, supply chains, terrestrial land use, coastal zones, new oceanic 'lands', climate, air pollution,

habitats and so on (an 'ocean farm to fork strategy'). In addition, emissions from underwater farming must be regulated and include the environmental impacts of transportation (e.g. fuels for harvesting vessels). Moreover, waste management policies must be extended to the oceans. By 2021, all coastal EU countries should have established maritime spatial plans; eight countries have not delivered in time (DG MARE, 2022).

Novel food and feed from the oceans pose certain **opportunities and risks** to human health and quality of life. For example, micro- and nanoplastics could become an ever more important threat to seafood safety. People need to become familiar with the new meaning of 'ocean food' in relation to 'terrestrial food', which requires appropriate communication and education measures. The relocation of food and feed primary production to the oceans might have unknown impacts (local and global). New collaborations between scientific disciplines (e.g. ocean science & agriculture specialists) will be necessary. Broad and scientifically sound technology assessment and risk assessment studies should inform decision-makers in 'food and feed from the ocean' policymaking. If the attention moves to the oceans, countries that have direct access to oceans will be privileged over landlocked countries. On a global scale, the exploitation rights of the seafloor may need a revision.

2.1.4 Peripheral perspectives on land use – towards the acknowledgement of diverse practices and culture in land use management

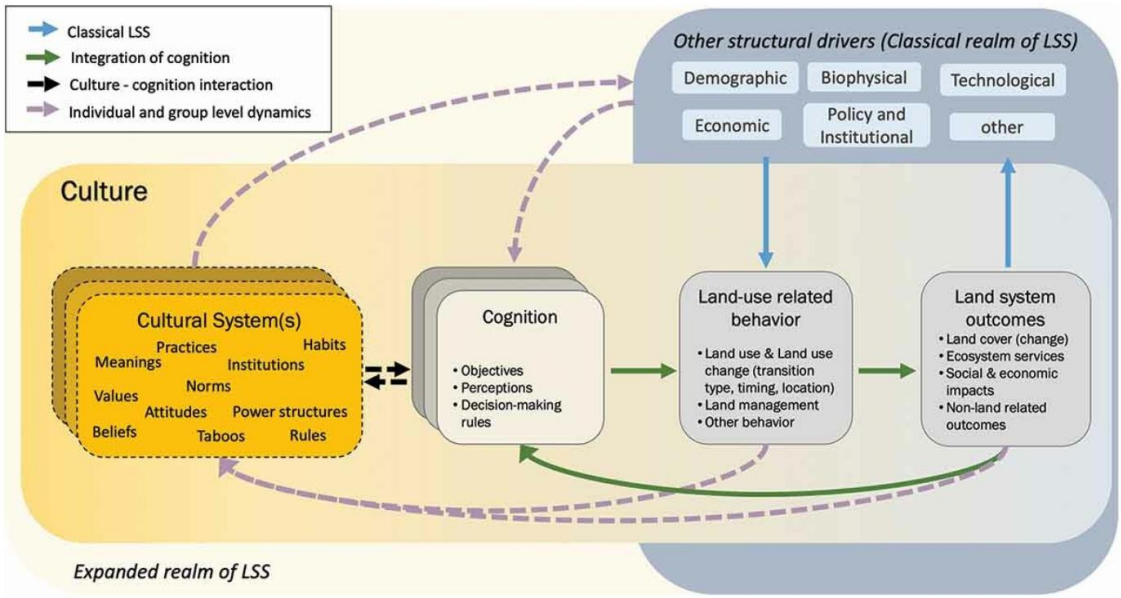
Description (What is it about?)

The meanings of land use are very diverse and often contested when zooming in at the local level. This results in different perspectives and unclear claims on land ownership, land tenure and land use (HU Berlin, 2022). The predominant land use governance mechanisms may not to take into account peripheral land use perspectives and the heterogeneity of contested cultural meanings sufficiently (Swyngedouw and Ward, 2022).

Unresolved land use issues have prompted the search for new perspectives and different voices. Examples include (1) the development of visions for rural areas from within, e.g., rural communities speak for themselves (Hofmann, 2022) or as a matter of speculative design (Rome University of Fine Arts, 2019), (2) viewing land use in Europe also from a non-Western perspective (e.g. food security claims raised by African countries), (3) taking into account informal uses of land (no formal documentation of land use, the actual use may be different from the intended use), (4) the acknowledgement of alternative land use approaches such as common land tenure, and (5) learning from land use governance abroad (e.g. South America, India). All these examples for peripheral perspectives relate to land use culture.

Research on the causal role of culture in land use systems has been limited in comparison to research on other fields such as climate change, markets and politics (de Warouw et al., 2021). It is a challenge to capture the cultural perspective, which explains why it is often neglected. However, the consideration of the cultural perspective in the predominant land use regime matters, as an increase in the number of activities accounting for peripheral perspectives indicates. The first conceptual models try to capture the role of culture in land use (Figure 2.2).

Figure 2.2 Conceptual model of the role of culture in land systems



Source: de Warouw et al., 2021.

Cultural systems embody all the practices, meanings, norms, values, attitudes, beliefs, institutions and power structures that related to other structural drivers and that are influenced by land use behaviour and land system outcomes. In this system view, the cultural system has a bidirectional relationship with cognition, i.e. perceptions, objectives and decision-making rules (de Warouw et al., 2021).

If peripheral perspectives on land use are taken into account and digital local land use planning and culture dominate over the current large-scale land use planning paradigm, this would bring about novel opportunities and risks to sustainable land use transitions.

Facts and figures (What is going on? What is new?)

There is no empirical data available on how far peripheral perspectives are integrated in land use research and management, for obvious reasons. The variety of land-use planning systems has been mapped by the OECD, identifying 229 different land use plans in 32 OECD countries and estimating the number of individual plans to be likely above 100.000 (OECD, 2017). The sheer size and variety of land use plans inhibits the formulation of simple hypotheses about the cultural dimension in these plans. The cultural dimension of land use has been always important; explicitly accounting for different perspectives and culture in land use planning and policy is emerging as an important prerequisite for land use transitions.

While the consideration of different perspectives and of the cultural dimension in land use entail even more complexity in land use planning, human-centred digital technology increasingly provides tools for dealing with different perspectives and complexity. Examples are 3D digital twins of cities, visualisation methods for community planning, volunteered geographic land use information and street view imaging techniques (Gravagnuolo et al., 2022). The use of digital technology in land use planning has its limitations. For example, the Copernicus Corine Land Cover observation does not detect land use changes below 5 ha and scattered urban sprawl (Ivits, 2020). However, digital technology expands the opportunities not only for more accurate land use planning, but also to account for different views and perspectives.

Implications (Why does it matter to land use and environmental policy?)

If peripheral perspectives were increasingly taken into account, biases in land use research and practice, and in regional narratives could be the basis for a more balanced representation of perspectives. Digitisation in spatial planning may assist the creation of novel solution spaces by integrating dominant and peripheral perspectives, leading to better and more broadly accepted solutions.

Calls for the development of 'local solutions' will become ever more frequent as the dominant general model solutions for land use could turn out to create trade-offs and conflicts under specific local conditions. Accounting for more diverse perspectives in the way we manage land is an emerging approach that could stimulate local land use culture and more diverse land use patterns.

The management of land use systems is a complex issue. Obviously, there are always trade-offs in land use change. A prerequisite for effective and successful land use planning is to define which benefits to prioritise, and for whom, and thus it includes value judgments. If **advanced human-centred digital technology** is used effectively in the context of smart circular city/region development different perspectives on land use and its cultural dimension could be accounted for much better than to date. Developing rural visions from within could direct land use planning closer to the local population's needs and thus slow down land abandonment and movement of people to the cities.

Climate change will have consequences for the relocalisation of production and people (inhabitants/consumers). This will cause significant changes to the fabric of the places where people live, work, and take leisure, and consequently to the emotional attachments associated with such places (Devine-Wright and Quinn, 2020). Practical solutions for land use at the local level could bring about **land use patterns** which serve multiple purposes either "side by side" (e.g. specialised forest areas), or "all in one" (e.g. mixed forest use). While there is a potential that such local land use patterns will be beneficial to the environment (e.g., permaculture with multiple synergetic outputs), the upscaling of sustainable solutions (e.g., for biodiversity) could be slowed down due to the local variations in perspectives and culture.

At the local administrative level, there are often conflicts of interest such as nature protection versus being an attractive place for commercial activities. Farmers, citizens, regional co-operatives, multinationals firms and many others might have a say in **land use planning**. If multiple perspectives are increasingly taken into account, it has to be reflected whose voices matter and in which way they are raised and considered in land use management. Outcomes of such practices could be the assignment of land to different or multiple purposes and multi-stakeholder arrangements, e.g. in marginal areas (e.g. public-private-people-partnerships, communal ownership and management, common good criteria in land tenure and trade). At the same time, the different and quickly changing regulatory frameworks for land use raise the question: how to ensure adaptive and responsive vertical governance and coordination that may be at odds with the cultural dimension of land use in a certain place.

Urbanisation and giving-up of agricultural production in the EU may export land-use problems to other world regions. If land in Europe is used for carbon sequestration instead of for crop production, it will not only change the agricultural markets, but also the values that are attributed to land. If there is a move towards local or national land use politics, the risk emerges that global impacts of land use will get out of sight. Land use futures in Europe could account for the stakes of people and populations from **outside Europe**.

If peripheral perspectives on land use are increasingly taken into account, the development of land use solutions will need to account for them in a **systemic perspective** that incorporates the environmental impacts of various land use practices (e.g. greenhouse gas emissions and footprint accounting). Action programmes for alternative land use could stimulate the search for multi-perspective solutions (ALUS Program, 2022).

2.2 Circular economy

2.2.1 Energy transition in times of energy crisis – a window of opportunity for a circular energy transition?

Description (What is it about?)

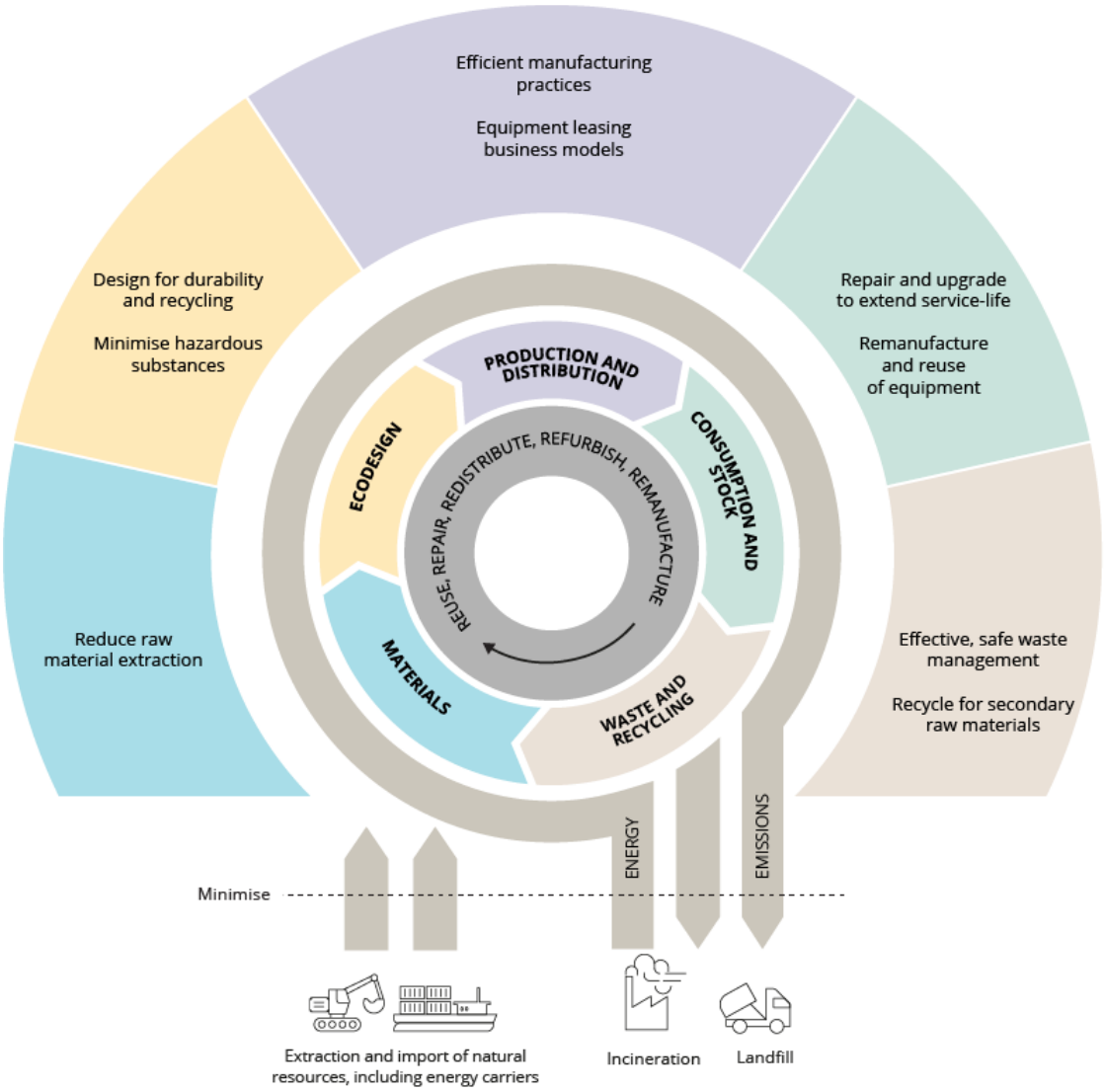
Many states in Europe are dependent on Russia's gas and oil exports. Russia is the world's largest exporter of oil to global markets, of which in 2021 about 60% went to OECD Europe. Moreover, Russia is the world's second largest producer of natural gas, of which the European Union imported 45% in 2021 (IEA, 2022a, 2022b). The Russian attack on Ukraine rattled energy markets e.g. by Russia manipulating gas supplies and interrupting gas deliveries to Europe. As a result, oil and gas prices rose to their highest levels in nearly a decade, forcing many countries to rethink their energy supplies (Tollefson, 2022).

Many governments immediately began taking steps to address the energy crisis by trying to find alternative fuel sources like liquefied natural gas (LNG), increasing electricity generation from oil and coal, extending the lifetimes of some nuclear power plants, or accelerating the flow of new renewable energy projects (IEA, 2022c). Also demand-side measures were taken like electricity demand reduction measures or redistributing the energy sector's surplus revenues to final customers (EC, 2022b).

Whether the current crisis could accelerate the transition to a sustainable energy, and in particular to a circular energy system in the longer term is still an open question. A big push could arise from the EU's REPowerEU plan, presented in May 2022, and the United States' Inflation Reduction Act, passed in August 2022, both containing major initiatives to develop energy efficiency and promote renewable energies (EC, 2022b). In the current unstable times, however, there are also risks for achieving a sustainability transition, for example if European countries lose their competitiveness in the search for a solution to the energy crisis and slip into a prolonged recession, or - a worst-case scenario - we end up in a third world war.

According to the EEA, a circular energy system could consist of the elements illustrated in Figure 2.3.

Figure 2.3 Circular energy system



Source: EEA, 2018.

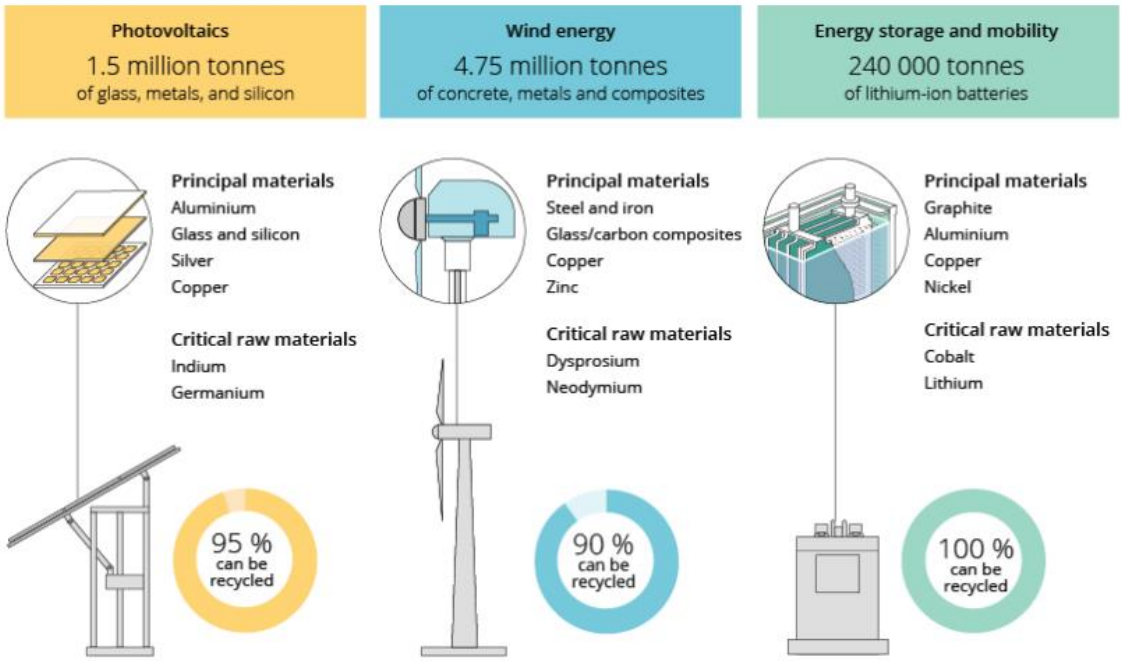
Facts and figures (What is going on? What is new?)

With the world in the midst of a global energy crisis, the World Energy Outlook 2022 provided an analysis on the implications for the future of energy systems across the globe and asked if the crisis will be a setback for clean energy transitions or a catalyst for greater action towards net zero emissions. Key findings are promising. Even the Stated Policies Scenario (STEPS) – the most conservative scenario that does not take it for granted that governments will reach all announced climate and energy targets - shows that:

- coal use falls back within the next few years, and natural gas demand reaches a plateau by the end of the decade
- new policies in major energy markets will help propel annual clean energy investment to more than USD 2 trillion by 2030, a rise of more than 50% from today (IEA, 2022c).

The energy crisis aside, the energy transition requires significant resources. According to the Oekoinstitut (2021), some of the renewable energy infrastructure installed decades ago was not designed according to the circular economy principles. It is thus inevitable that its waste will increase rapidly in the coming years, opening opportunities for moving toward greater circularity (Figure 2.4).

Figure 2.4 Material recovery opportunities arising annually from the clean-energy sector by 2030



Source: EEA, 2021.

Implications (Why does it matter to land use and environmental policy?)

The circular economy is often ignored in current political activities around the energy transition, even though there are synergies and conflicting goals between the circular economy, the energy transition and climate change. With the increased urgency in dealing with energy supply, there is now a window of opportunity to bring the topic to the forefront and increase visibility for the circular economy. The International Energy Agency (IEA) observed that many governments are now seeking to increase or diversify oil and gas supplies. Many also want to accelerate structural change. As a positive development, the IEA noted the Inflation Reduction Act in the U.S., the Fit for 55 package and REPowerEU in the EU, Japan's Green Transformation (GX) program, Korea's goal to increase the share of nuclear and renewables in its energy mix, and clean energy targets in China and India. In light of these political responses, the energy crisis could become a historic and definitive turning point towards a cleaner, more affordable, and more secure energy system (Solarserver, 2022).

Recent crises have exposed the vulnerability of supply chains, particularly for energy and food. This might be an opportunity for a shift to more locally based production systems, for keeping raw materials in the loop, and for building more resilient structures and probably even economic benefits in establishing Europe as a leader in circular energy systems, as there could be global export opportunities for this know-how.

An existing risk is that countries/governments are currently making hasty policy decisions and refocusing on fossil fuels to stabilise their energy system ("energy crisis panic").

The effectiveness of the circular economy depends on market conditions and policy incentives. Currently, the EU and many Member States are implementing actions to address the energy crisis and support Ukraine. All these support programmes and policies need to adjust economic incentive structures, address redistribution and regulate profit motives according to circular economy strategies and conditions. Regulatory requirements might also be important at certain points, e.g., regulations to recover valuable raw materials from retired energy systems for use in new infrastructure (lithium, steel, etc.), since even a circular energy infrastructure relies on raw materials.

With rising prices and inflation, the financial pressure on citizens increases. There may be a window of opportunity where consumer behaviour shifts from "constantly buying new products" to a new view that embraces the benefits of a circular economy such as energy efficiency, sufficiency, product longevity, etc.

2.2.2 The reality of circularity – upcoming challenges to prevailing circular economy concepts and mindsets

Description (What is it about?)

How circular is the circular economy in reality? According to the Circularity Gap Report 2022, the answer is that currently, our world is only 8.6% circular, which leaves a massive Circularity Gap of over 90% (Circle Economy, 2022).

Even, if there is still a long way to go, the vision of a circular economy is becoming more and more popular. Many countries across the world have made the transition to a circular economy one of their policy priorities (OECD, 2022). Similarly, the EU sees the circular economy as one of the main building blocks of the European Green Deal (European Commission, Directorate-General for Communication, 2020).

But there are also other voices that doubt that a circular economy can be achieved at all. Several scientific studies describe the circular economy as an "idealised vision" (De Decker, K., 2018) or call it even “dangerous as it not only creates illusions of a waste-free world but also fails to address the huge efforts that are really needed to create a sustainable economy” (Lehmann, H., Hinske, C., de Margerie, V., & Slaveikova Nikolova, A. (Eds.), 2022)

There are a number of critiques addressed to the circular economy that point out why achieving the vision of a 100% circular economy is unrealistic, namely:

- Energy is always required to maintain pure materials.
- The production of renewable energy has always an ecological footprint, because building renewable energy infrastructure causes negative ecological impacts.
- There are always negative environmental impacts created by logistics that are needed for closing all material cycles (Lehmann, H., Hinske, C., de Margerie, V., & Slaveikova Nikolova, A. (Eds.), 2022).
- Many products are too complex to be recycled. A recent study of the modular Fairphone 2 – a smartphone designed to be recyclable and have a longer lifespan – shows that the use of synthetic materials, microchips, and batteries makes closing the circle impossible. Only 30% of the materials used in the Fairphone 2 can be recuperated.

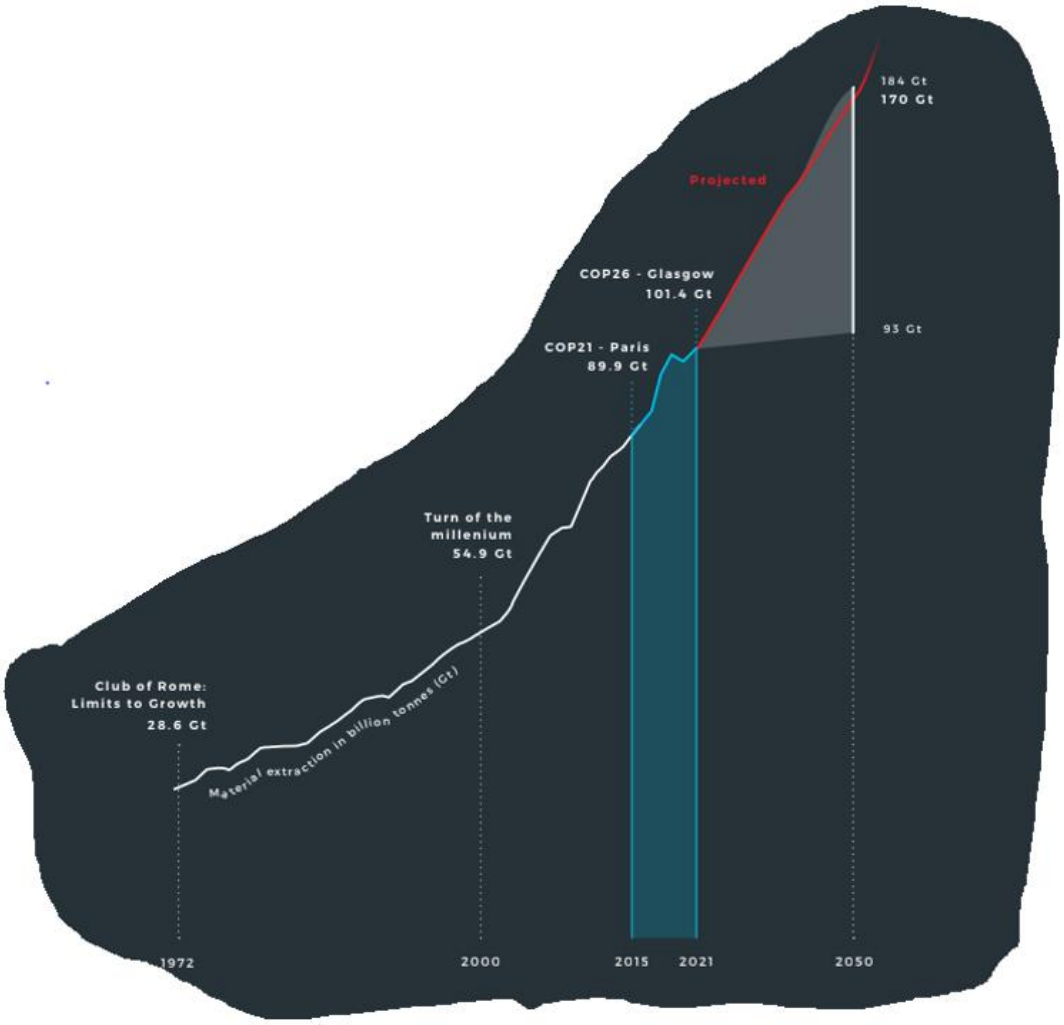
- Economic growth makes a circular economy impossible, even if all raw materials were recycled and all recycling was 100% efficient. The amount of used materials that can be recycled will always be smaller than the materials needed for growth (De Decker, K., 2018).

What does this mean for policy makers, companies, institutions, or civil society organisations who have committed to a circular economy vision and are spending their resources in achieving it? Did they all bet on the wrong horse? Or is it rather about bringing a bit more realism into the debate in a scientific sense: how far is a circular economy achievable and where do we have to find other strategies such as how to move away from continuous economic growth or other strategies?

Facts and figures (What is going on? What is new?)

In the last 50 years, the global use of materials has nearly quadrupled, and even between the COP 21 in Paris and the COP 26 in Glasgow more than half a trillion tonnes of virgin materials were consumed (Figure 2.5). Forecasts paint a grim future: according to the International Resource Panel, material use may increase to between 170 and 184 billion tonnes in 2050 if business as usual prevails (Circle Economy, 2022).

Figure 2.5 The material extraction in billion tonnes (Gt) from 1972 to its projected rates in 2050 if business-as-usual prevails



Source: Circle Economy, 2022.

According to the Circularity Gap Report (2022), the global circular economy has actually declined from 9.1% in 2018 to 8.6% in 2020.

There is an emerging critical attitude towards the feasibility of the vision of a circular economy. The discourse on this is not new. Even in the 1960s, Georgescu-Roegen warned against exaggerated expectations of recycling in his book "The Entropy Law and the Economic Process", pointing to the enormous amounts of energy needed to extract recyclables from waste (Lehmann, H., Hinske, C., de Margerie, V., & Slaveikova Nikolova, A. (Eds.), 2022). The paper “Critiques of the circular economy“, published in 2021, analysed studies by a large number of authors criticising the circular economy (Corvellec et al., 2022). The debate has not yet fallen silent as the publication of the book “The Impossibilities of the Circular Economy” shows (Lehmann, H., Hinske, C., de Margerie, V., & Slaveikova Nikolova, A. (Eds.), 2022).

Implications (Why does it matter to land use and environmental policy?)

The literature on the limits of a circular economy seems to agree that there is a need for more realism in the debate (see (Corvellec et al., 2022) (Lehmann, H., Hinske, C., de Margerie, V., & Slaveikova Nikolova, A. (Eds.), 2022)). To do so, a whole range of different proposals are made, which cannot all be presented here. These include, at a fundamental level, the need for:

- recognising the limits of the circular economy
- shaping concepts and definitions acknowledging physical/natural limitations
- a holistic understanding and more system thinking

and, on a more specific level, by noting

- that metrics are lacking when it comes to performance measurements because it is debatable what actually needs to be measured
- that the avoidance of conflicting sustainability goals and conflicting goals in various resource nexus are critical and must be evaluated for individual materials and products
- the geographical dimension e.g. by shifting some of the burden (waste, processing, etc.) elsewhere or the role of the local level
- the interrelationships between degrowth and the circular economy
- the importance of bringing in the “social” dimension by acknowledging the implications of hegemonic norms and values, practices, and rules have on a circular economy (Lehmann, H., Hinske, C., de Margerie, V., & Slaveikova Nikolova, A. (Eds.), 2022).

2.2.3 Rethinking bio-based materials – innovations are needed?

Description (What is it about?)

Shoes made not from animal leather but from mycelium fibres, car tyres 100% made from dandelion-based natural rubber instead of petroleum-based polymers, or carbon fibres in aeroplanes made of algae - in times of raw materials scarcity and increasing environmental pressures, bio-based materials promise a sustainable alternative to fossil-based alternatives.

Bio-based materials consist of a substance (or substances) derived from living matter (biomass) that either occurs naturally or is synthesised. Following a strict definition, many common materials, such as paper,

wood, and leather, can be referred to as biobased materials, but typically, the term refers to modern materials that have undergone more extensive processing (Curran, 2010).

According to Mc Kinsey (2021) there are three different biomaterial product types: drop-ins (existing materials such as nylon and spandex created through bio-routes), bio-replacements (sustainability-oriented clothing created using biomass waste streams), and bio-better (Biotech versions of biomaterials such as leather and silk for improved performance and sustainability profiles).

In recent years, the range of plants used to produce bio-based materials has steadily expanded, e.g. with dandelions, grasses, straw or castor seeds, a material used as a basis for plastics. Recently, mycelium has come onto the scene as well as microorganisms and enzymes. Even organic residues and waste materials are increasingly coming into focus as a valuable basis for biobased materials (Biooekonomie, 2018).

The potential application areas for bio-based materials are enormous. Sectors that are currently in particular focus include the packaging sector, construction & architecture, automotive, textiles, pharmaceutics & cosmetics, food, and many more.

Biomaterials with novel properties allow products to become “smart” and unlock new products that do not exist today. In the first category are bio-based materials that react to different conditions, such as pressure, light, humidity or temperature. MIT researchers, for instance, have combined the same enzyme fireflies use, luciferase, with a chemical receptor in plants called luciferin to make the leaves of trees glow and replace streetlights.

Another promising category is biobased materials that can repair themselves, extending the lifetime of the product. For example, shoes can be made from a smart bio-based material that repairs the damaged area.

Next, there is the category of intelligent degradation and self-extinction. Currently, huge amounts of plastic waste end up in nature. Plastic-decomposing enzymes have already been discovered, but at present bioplastic could be made in such a way that a certain combination of water and salt triggers the decomposition of the material.

The next category is biocomputing. Biocomputers use cells or their sub-molecules (such as DNA or RNA) to perform functions traditionally done by an electronic computer. Improvements are expected, for example, in storing data in DNA, performing computations and processing data without consuming much energy and without heating up much, performing multiple computations simultaneously using myosin-activated biocomputing, or being able to better self-organise and self-repair (Ray, 2021).

And last but not least, bio-based materials are used in humanoid robots, if bioactuators enable the successful grasping of objects (Xu, 2022).

Biomaterials are often discussed as a central element of a bioeconomy, which is considered a “central element to the functioning and success of the EU economy (…) [and] “needs to have sustainability and circularity at its heart” (European Commission, Directorate-General for Research and Innovation, 2018). A number of innovations may become important in the bioeconomy of tomorrow, including biopolymers and biocomposites, wood-based materials, new biomass sources such as fungal biomass, or biorefining, the processing of many kinds of biomass into a spectrum of marketable products, such as food, feed, fibres, bulk and fine chemicals and fertilisers, and energy, including biofuels, power and heat, using biotechnology (EEA, 2018).

Facts and figures (What is going on? What is new?)

Biomaterials are on the rise. The bio-based industries' total contribution to the EU's bioeconomy in 2019 was over 814 billion EUR, according to the latest available data in Eurostat, this represents an increase of 34 billion EUR (+4%) compared to 2018 (Bio-based Industries Consortium, 2022).

These growth rates were enabled by progresses in process technologies e.g. made by new discoveries in microbial, chemical, and genetic engineering research to convert plant materials into useful products.

Some biomaterials show a particularly high growth rate:

- Spider silk protein has grown. Spider silk protein is used for example in cosmetics, medical technology, and in the automotive industry.
- Mycelium production is also rapidly scaling e.g. to produce fungi-based bacon, leather, or foams (Xu, 2022).

Implications (Why does it matter to land use and environmental policy?)

Bio-based products are considered to contribute to sustainability due to their functional advantage of replacing fossil-based products.

However, every innovation or new technology might also introduce new challenges. Some bio-based materials may be more sustainable than others. Some bioplastics, for example, are biodegradable, but others are not. Policy interventions should be geared towards the reduction of environmental pressures along the entire value chain. Standards and regulation are needed urgently.

In addition, the more the demand for food, feed, biomaterials and bioenergy resources increases, the more this could lead to intensified pressure on natural resources and conflicts between supply and demand (EEA, 2018), for instance, putting more pressure on land use. This pressure is expected to increase as climate change progresses. Encouraging vertical farming and other sustainable non-land-farming methods to reduce pressure on land use and keep up with the demand on biomaterials could be a solution.

Circularity can help to reduce competition for land and aquatic resources and thus contribute to the mitigation of climate change and biodiversity loss. In a sustainable and circular bioeconomy, resources should be kept in use for as long as possible through cascading biomass use and recycling, while ensuring that natural capital is preserved (EEA, 2018). Opportunities for job creation and technological innovation would have a local impact and support the local economy and society. Ensuring that biobased materials are truly sustainable, however, needs systemic thinking. Materials should only be produced if they are needed for an actual use. Single-use plastic, even if it is compostable bioplastic, is still a resource we waste. Where are the potentials for sufficiency, and change of consumer behaviour? An underpinning shift in mindset is needed.

2.2.4 Geopolitics & the circular economy – framework conditions in turmoil

Description (What is it about?)

The world order as we know it is in a period of upheaval. Russia attacked Ukraine on February 24, 2022, triggering a war in Europe that is still ongoing. China´s becoming increasingly authoritarian, claiming democratically governed Taiwan as its own territory and increasing its military pressure. In early 2022,

China and Russia formed an "alliance of autocracies" and intensified economic trade. Whether the United States can live up to its role as leader of the Western world is unclear because of domestic instabilities such as the increasing radicalisation of large segments of the population. The EU is caught between a rock and a hard place, searching for its role in the world. How it will all develop is uncertain.

Russia's military aggression against Ukraine is leading to massive social and economic impacts, particularly food and energy shortages, supply chain disruption, and migration. The EU, for example, is on a path of lower growth and higher inflation. Rapid increases in energy and food prices are adding to global inflationary pressures, eroding household purchasing power and leading to monetary policy adjustments (EC, 2022c). A new survey in France, Germany, Poland and the United Kingdom has shown that many Europeans fear that high inflation due to the current energy crisis could lead to social unrest, protests and strikes (Euronews, 2022).

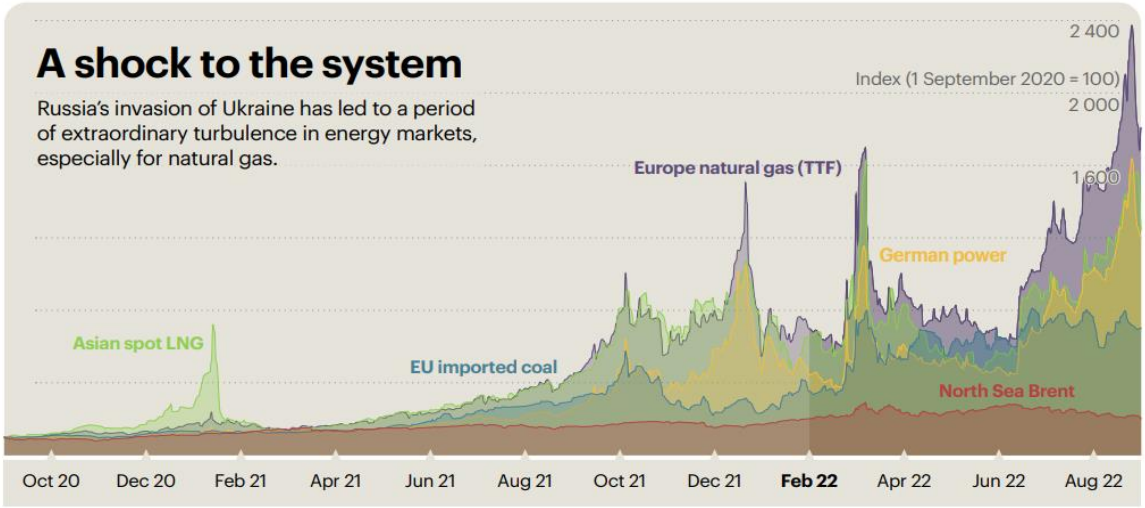
Facts and figures (What is going on? What is new?)

Russian´s war against Ukraine worsens the economic outlook:

- Global growth is forecast to slow from 6.0 percent in 2021 to 3.2 percent in 2022 and 2.7 percent in 2023.
- Global inflation is forecast to rise from 4.7 percent in 2021 to 8.8 percent in 2022 but to decline to 6.5 percent in 2023 and to 4.1 percent by 2024 (IMF, 2022).

Russia´s invasion of Ukraine has led to a period of extraordinary turbulence in energy markets, especially for natural gas (IEA, 2022c), see Figure 2.7.

Figure 2.6 Shocks in the energy market



Source: IEA, 2022c.

Implications (Why does it matter to land use and environmental policy?)

As it is not clear at this stage what the new world order will look like, it is difficult to assess the precise implications for European environmental policy, and the circular economy in particular. According to the Bertelsmannstiftung (2021) a lot will probably depend on the future positioning of the EU vis-à-vis the US and China.

Depending on Europe's "strength/weakness" and the degree of cooperation between the USA and China, Europe´s environmental and circular economy policies could become more regional but embedded in a reformed global governance (see 'performed multilateralism') or it could be torn between USA and China (see 'world in permanent crises'), to name two possible scenarios. Europe's ambition for a green and digital transition is only possible with a massive increase in the supply of raw materials needed for the production of chips, electric vehicles and renewable energy technologies (Taylor, 2022). However, China holds a monopoly in several sectors. In May 2022, the EU announced a legislative proposal - the Critical Raw Materials Act - to reduce its dependence on third countries e.g. by expanding mining in Europe, by investing in circular economy and recycling, and by diversifying supply chains (Noyan, 2022). A circular economy can be an important element for achieving resilient supply chains.

Establishing resilient supply chains could also be a solution in overcoming shortages of energy and food supply. Renewable energy could become an important energy source for the circular economy, and locally produced food could reduce imports and foster a local circular economy.

One risk could be that governments are under so much pressure to act quickly during emerging crises, such as the current energy and food crises, that they pay little attention to aspects around the circular economy. Another environmentally relevant issue on the EU's political agenda could become the support for Ukraine's reconstruction, and whether it is guided by circular economy principles.

A crucial open question is how Europe's economic outlook will develop and what will the financial scope be for building a circular economy in an unstable geopolitical situation.

3 Conclusions

The Eionet participatory horizon scan with its twofold aims (1) to identify a set of important emerging issues in the realms of land use and the circular economy and (2) to strengthen horizon scanning capacities and stimulate learning among Eionet members produced eight emerging issue characterisations.

The emerging issues identified include tangible subjects such as agrivoltaics, bio-based materials, the circular energy transition, and food and feed from the ocean, but also fuzzy, difficult to grasp subjects such as geopolitics and the circular economy, the reality of the circular economy, the human-nature relationship and peripheral land use perspectives. Of course, there are more solid facts and figures for the tangible subjects. However, the other topics are not less important as they point at the need to frame our environmental topics differently, which could prompt other ways of thinking about them.

The outputs of this participatory horizon scanning exercise (i.e. weak signal dossiers, candidate theme reports and this emerging issue report10) could serve as a knowledge base for communication activities within the countries such as newsletters, website presence, expert-webinars, development of infographics, or even smartphone apps with information on emerging issues. Moreover, they could be used to build visions in European or national environment strategies or sustainability strategies, support the identification of new research topics or research gaps, select deep-dive studies, inform other foresight studies (e.g. megatrend analysis, scenario development), political and public dialogues, policy gap analyses, to stress-test policies, and make policy recommendations that build preparedness.

[10] Available on the Eionet Forum: https://forum.eionet.europa.eu/eionet-foresight-group/library/horizon-scanning/2022/outputs

Horizon scanning processes can contribute to strengthen the collaboration within and amongst the Eionet Groups on Foresight and SoE, other Eionet Groups, and actors. It can be a tool for involving the youth and other vulnerable and minority groups to make sure that all voices are heard, as well as non-governmental organisations and green-minded change makers.

List of abbreviations

Abbreviation	Name	Reference
EEA	European Environment Agency	www.eea.europa.eu
EG	Eionet Group	
Eionet	European Environment Information and Observation Network	www.eionet.europa.eu
ETC ST	European Topic Centre on Sustainability Transitions	www.eionet.europa.eu/etcs/etc-st

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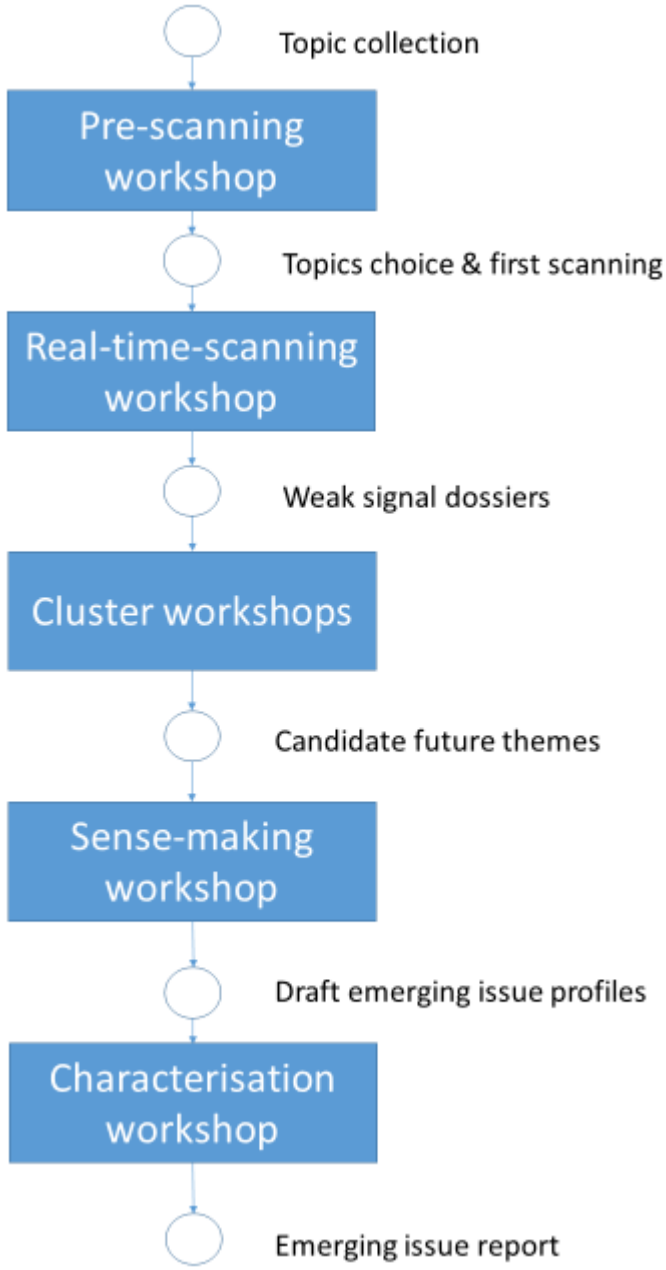
Annex 1. Methodology

The methodology used in the Eionet participatory horizon scanning pilot 2022 is summarised as follows:

Figure A1.1 Methodology – the workshop series with intermediate steps



Prior to the fist 'pre-scanning' workshop, topics were collected from previous exercises and by seeking input from Eionet participants actively. At the pre-scanning workshop (4 May 2022) which was held online, participants chose the topics 'land use' and 'circular economy'. In addition, they were provided with a few generic source pools which they could browse for weak signals. Participants also scanned for further sources and captured weak signals in a template.

The second ‘real-time scanning’ workshop (21 June 2022) was informed by a systematic pool of sources for land use and circular economy respectively. Participants scanned in real time the online sources and assigned the weak signals to the categories society, technology, economy, environment and policy (STEEP). The weak signals were given a title, a description and hypotheses about their relevance with regard to land use/circular economy and the environment. The weak signals identified in the pre-scanning workshop, the real-time scanning workshop, further sources identified by the ETC project team and additional search provided the basis for the writing of two weak signal dossiers, one on land use (60 weak signals) and one on the circular economy (40 weak signals).

The two weak signal dossiers were submitted to the members of the Eionet Green shifts and horizon scanning sub-group who met on 5 and 6 September 2022 to cluster signals into candidate themes for the circular economy and land use respectively. The ETC project team then wrote short profiles for these candidate future themes (or emerging issue candidates) along the structure ‘what is it about?’, ‘what is new?’ and ‘what is the relevance for land use/the circular economy and the environment?’

These 17 candidate future themes were fed into a ‘sense-making’ workshop (14 September 2022), in which 8 themes, 4 for land use and 4 for the circular economy, were chosen for a deeper investigation. This workshop made use of the future wheel approach (Snyder, 1993) that mapped emerging impacts on the environment in an inner circle and the respective emerging policy action needs as a second order impact in the outer circle.

The ETC team drafted 8 emerging issue characterisations based on the input provided at the sense-making workshop and by drawing on additional literature research. Key characteristics and the mind-maps of these emerging issue characterisations were presented to Eionet participants on the ‘characterisation’ (and use) workshop (23 November 2022) with the aim to sharpen and enrich the current characterisations. To this end, the amplification of weak signals approach was employed to imagine how the emerging issues would look like if the principle would be transferred to another group or sector, become mainstream or even radicalise (Schirrmeister and Warnke, 2013).

Finally, the ETC reviewed all the inputs generated over the course of this Eionet participatory horizon scan and condensed the findings into this ‘Emerging issues report’.

Annex 2. Weak signals constituting the emerging issues

Table A2.1 Land use

Emerging issue	Underlying weak signals
Agrivoltaics, portable wind turbines & others – multi-purpose and flexible land use in view of the energy transition	8 Agrivoltaics 16 Portable Wind Turbine
Rethinking the human-nature relationship – from novel perceptions to the 'Rights of Nature'	5 Multi-species ecosystem flourishing 29 More countries commit themselves to the rights of nature 37 Changes in landscape perceptions: soundscapes, lightscapes and smellscapes 42 Language's role in nature perceptions 44 Place attachment in a changing world
Novel food and feed from the oceans – food without land	56 Novel foods could reduce land use by 80% 59 The global fat and protein supply challenges 61 Future challenges for the safety of food and feed from the oceans
Peripheral perspectives on land use – towards the acknowledgement of diverse practices and culture in land use management	21 Common land use rights limiting private property 22 Digitalisation of spatial planning 23 Diverse meanings of land use and contested land tenure/land-use claims 27 Land use from a non-western perspective 30 Rural futures from within 31 Shared vision and collective skills to reformulate social choices 33 Support alternative land use ideas and practices 40 Facts and biases in land use research 41 'Invisibility' of housing precarity in small peripheral municipalities: less land use efficiency 44 Place attachment in a changing world

Table A2.2 Circular economy

Emerging issue	Underlying weak signals
Energy transition amidst an energy crisis – window of opportunity for a circular energy transition?	24 The war on Ukraine affects EUs raw material deliveries 33 Quick grown urban forests with Miyawaki method
The reality of circularity – upcoming challenges to prevailing circular economy concepts and mindsets	4 Shared social responsibility – putting theory into practice 7 Imaginaries of circularity 8 Too uncritical attitude towards the circular economy? 18 Shared factory: A new production node for social manufacturing in the context of sharing economy 23 How circular is the circular economy? 28 OUR WORLD IS ONLY 8.6% CIRCULAR. 29 Moving from linear to circular business model is challenging 30 Consumption of metals continues to rise 31 Economic system incentivises waste that slows circular economy transition 32 Radical changes are needed for transformations to a good Anthropocene
Rethinking bio-based materials – innovations are needed?	7 Imaginaries of circularity 14 3D printing of food reduces food waste 15 Materials made from mycelium 17 Enabling a circular economy for chemicals in plastics 20 Bioplastics and CE 21 Bacterial biofactories turn CO_2 into useful chemicals 34 WOOD for Circular Economy 36 Strategic knowledge management crucial for eco-innovation processes
Geopolitics & the circular economy – framework conditions in turmoil	24 The war on Ukraine affects EUs raw material deliveries 30 Consumption of metals continues to rise

Annex 3. Food for thought - further emerging issues for exploration

This Annex presents the short profiles of the seven emerging issues that were candidates for further exploration but were not selected for characterisation. They are presented here so that they can be further explored by those interested in it.

Next to the title of each emerging issue candidate are the numbers of the weak signals underling it. The content of these weak signals can be retrieved from the weak signal dossiers on land use and on the circular economy respectively.

Each emerging issue candidate profile gives a brief description what the issues is about, indicates what is new and depicts hypotheses on its potential relevance for land use or the circular economy and the environment in general. Finally, the novelty and relevance of the emerging issue candidates are tentatively assessed.[11]

A3.1 Land use

Glow in the dark trees – a green infrastructure to replace streetlights [55, 57]

Bioluminescence is the phenomenon of light generation and emission by living organisms such as fireflies. Bioluminescence could be used for human illumination purposes.

Research is exploring the storage of bioluminescent algae in a glass tube thereby creating a mini ecosystem emitting light. The leaves of plants have been successfully prompted to glow by incorporating the firefly enzyme luciferase. The long-term vision is to use bioluminescent trees to light city and suburban streets. Such trees would be self-sufficient and not need human energy supply. Research aims at increasing light intensity for illumination purposes indoors and outdoors.

Glow in the dark trees have the potential to illuminate land. In substituting streetlights, they would reduce the need for streetlight energy. With its lighting function, trees would create additional value to urban heat island prevention, biodiversity and a pleasant ambient environment, thereby fostering its status as a green infrastructure.

Novelty: high

Relevance: medium

Direct Air Capture – less land area need for carbon removal than reforestation [12, 20]

Direct Air Capture (DAC) counts among the Carbon Dioxide Removal (CDR) technologies. It uses the selective affinity of carbon to sorbents, thereby allowing the other air components to pass through. The sorbent is regenerated through heat or electrochemically. Carbon Capture is followed by recycling or storage of carbon.

[11] Other clusters of weak signals with insufficient novelty and/or relevance were not considered to be emerging issue candidates and are therefore not displayed.

Companies such as Climeworks and Carbon Engineering have developed DAC to Technology Readiness Level 6, i.e. the large-scale and prototype phase. Meanwhile, the USA have launched a regional DAC Hub programme to achieve its climate targets. It aims at reaching market maturity and scaling up of DAC technology. In Europe it might be an option in countries with abundant marginal land such as Spain.

It has been shown that climate change mitigation technologies can have significant adverse impacts on land use, agricultural markets and food security. Compared to other types of carbon removal such as reforestation, DAC uses relatively little space for the site itself and the required energy infrastructure. DAC can be sited flexibly, thus avoiding land use competition and can be built on marginal land.

Novelty: high

Relevance: medium

Plants in the Internet of Things – new qualities of knowledge for land use management [58]

Plants can be combined with Information and Communication Technologies by using electrodes. Thereby "communication" with plants is enabled. Plant signals can be detected, and plants can receive signals.

Science has been successful in combining plants with digital technology recently. Internet-of-Things (IoT) technology is used to monitor forest areas which would normally be inaccessible or too costly to reach. Plants are transformed into sensors (e.g. carbon nanotubes in spinach leaves) to detect explosives (e.g. nitroaromatics) and send information back. In the long-term IoT-technologies could enable individual plant control for agricultural purposes.

It is expected that IoT-Technology will deliver the data to understand plants and ecosystems better in view of climate change and biodiversity, which may contribute to the long-term existence of forests, arable land and protected areas. At the same time IoT-Technology enables particular land uses in detecting plant health and environmental conditions.

Novelty: high

Relevance: medium

Land-sea boundaries in question – new land versus land take [4, 18, 52, 54]

In places and times of land scarcity, land is reclaimed from the sea for human purposes. At the same time, coastal shorelines alter their shapes due to climate change and human activity. Taken together, these two developments point at a renegotiation of the land-sea boundaries.

Rising sea levels and extreme weather events attack existing shorelines. Illegal sand grabbing for commercial reasons contributes to the pressure on coastal subsea soil and beaches. Prosperous areas with land restrictions are well known for their land reclamation efforts. Artificial Islands for human settlement are planned in Europe, facing stiff opposition. Singapore recently presented a concept for floating solar parks and the Maldives started to market apartments built on artificially reinforced reefs. UN Habitat has called to develop floating cities to adapt to climate change.

There is an increasing need to promote resilient and sustainable uses of coastal land. For land reclaimed from the sea novel land use regimes need to be established. Both pose different but intertwined challenges to spatial planning.

Novelty: medium

Relevance: medium-to-high

A3.2 Circular Economy

The next level of virtualisation – rebalancing de-materialisation and re-materialisation [1, 5, 9, 11, 22]

Digitalisation continues to progress. More and more areas of life are taking place virtually: Shopping takes place online, friendships are maintained on social media and computer games are played online.

With Covid-19 and new digital innovations such as the Metaverse, artificial intelligence or virtual reality, virtualisation is reaching a new level. This is changing society. People are nestling in the comfort of their homes or favourite places abroad, connected online to the outside world that is becoming more and more a virtual world. People visit in this virtual copy of society shopping centres, go to learning and working spaces or immerse in their next exciting holidays. Even the personal sphere is changing, if people are making friends with digital twins or work with the digital twins of their colleagues.

Virtualisation has the potential for im-materialisation. Thesis: the more areas of life wander into the virtual world – the more immaterialised the world can be.

Digital infrastructure needs a lot of resources – is a circular & sustainable infrastructure thinkable?

Novelty: medium

Relevance: high

Production for & in a circular economy in turbulent times [13, 14, 16, 21, 25, 33]

A circular economy is a model of production and consumption, which involves sharing, recycling, repairing, refurbishing, remanufacturing etc. of products as long as possible. That requires economic changes and lively innovations, also of production processes. All the transitions happen in very dynamic times (climate change, geopolitical shifts). Not all sustainable innovations align with CE.

There is a lot of innovation in production processes needed e.g. circular 3D-Printing

There are goods (e.g. wind turbines, photovoltaic panels) that are not immediately compatible with a CE

Adaptive innovations are needed that address changing conditions

Innovations push the circular economy

External developments are difficult to change – you can only react and adapt your innovation

Consequences of unexpected events (Covid-19, attack of Russia on Ukraine etc.) are extra-difficult to deal with

Novelty: medium

Relevance: high

Accelerating innovation for sustainable transition - the Miyawaki method as a metaphor for the rapid production of a resilient biological stock [33]

Miyawaki is a method to grow a forest within 20 years instead of 100. The Miyawaki method can be seen as a metaphor for speeding up the usually slow biological processes and responds well to the urgency requirements of sustainability transitions. With Miyawaki, 3 to 5 saplings are planted per square meter with a minimum different species, creating a multi-layered green forest with no maintenance required after a 2 – 3 year´s period.

In times of climate change, forests are under pressure – at the same trees are needed to tackle climate change and to have green spaces especially in urban areas. Miyawaki has the potential to green the world quickly.

Moreover, a Miyawaki grown forest could deliver the resources for a circular economy.

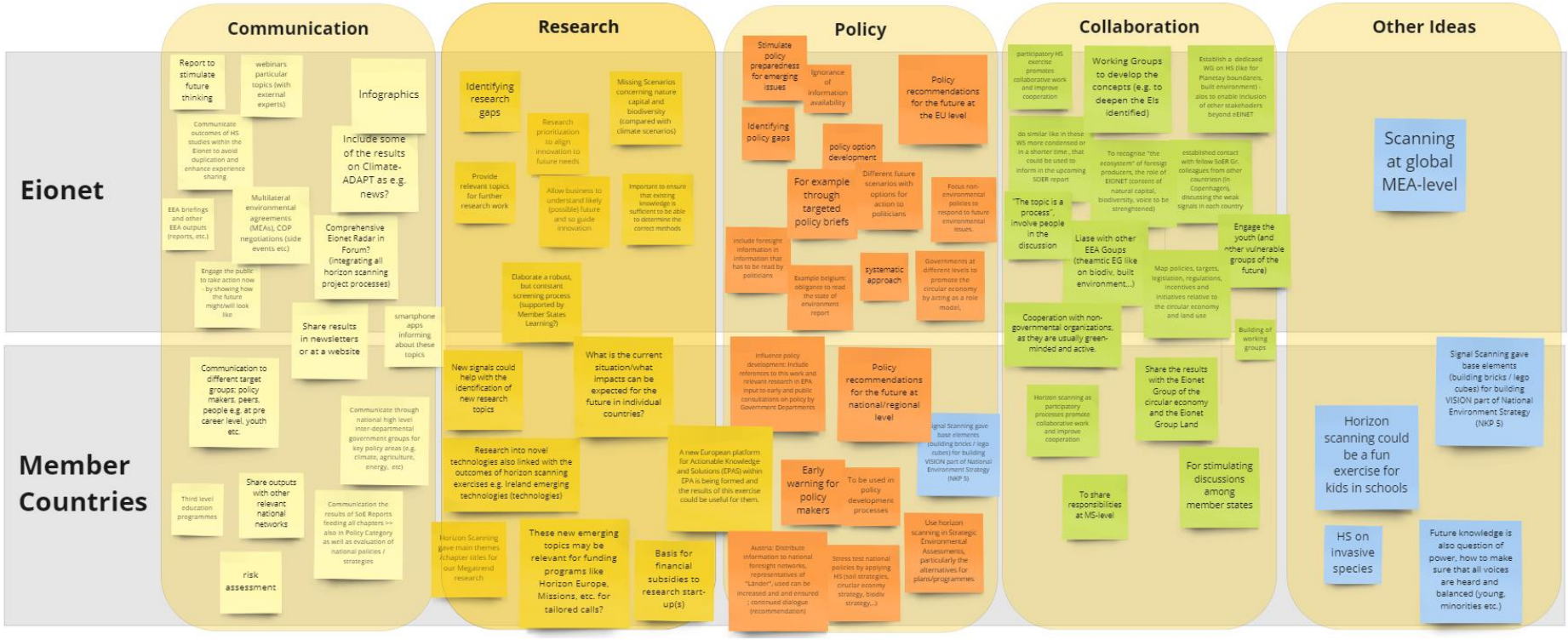
What are other innovations that accelerate the transition towards CE and sustainability?

Novelty: high

Relevance: high

Annex 4. Brainstorming results on ideas for using the eight emerging issues

Figure A4.1 Ideas provided by workshop participants for using the eight emerging issues described in the report



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