Foto: © Microsoft

Futures of using nature in rural and marine Europe in 2050

Scenarios and policy implications

Authors:
Totti Könnölä, Insight Foresight Institute
Martha Bakker, Wageningen University & Research
Francois Simard, International Union for Conservation of Nature
David Shaw, University of Liverpool
Philine Warnke, Fraunhofer Institute for Systems and Innovation Research

DRAFT

August 1, 2023

Futures4Europe Policy Brief 1/2023

Funded by
the European Union

Table of Contents

Summary

The immense social and technological evolution of the Anthropocene continues transforming the Earth's surface and its dynamics through extensive (mis-)use of its resources, both on the land and in the sea. This policy brief develops scenarios on rural and marine areas in Europe in 2050 and subsequent implications to today's R&I policy in Europe. Each scenario considers i) Economy and technology, ii) Demographics, lifestyles and values, iii) Governance and iv) Environment.

In Scenario A, European Civic Ecovillages pursue self-sufficiency and contribute to establishing a cooperative, locally oriented, caring economy restoring the ecosystem carrying capacities in land and sea. In Scenario B on Sustainable High-tech Europe, European businesses enjoy global leadership in regenerative and multi-functional high-tech solutions for energy, aquaculture and agriculture. In Scenario C on the United States of Europe, centrally planned Europe is divided between intensive use of land and sea and large conservation areas. Scenario D on European Permacrisis portrays Europe in a post-growth and politically scattered context that leads to low rates of innovation and fragmented use of land and sea.

None of the scenarios features a decisive solution to the global climate and biodiversity crises. Scenario A forcefully targets the resolution of the biodiversity crisis in Europe, by aligning human practices with nature, but provides little support to global climate and biodiversity crises. Scenario B proactively tackles the biodiversity crisis both in Europe and internationally but struggles with the fragmentation of efforts and with scaling up good practices and wider impact to curb the crisis. Scenarios C and D with intensive use of nature reduce biodiversity. Thanks to European-wide coordination Scenario C can protect vast areas with positive impacts to biodiversity, whereas Scenario D also struggles with the major fragmentation of conservation efforts and its detrimental impact on biodiversity. Such challenges illustrate the importance of balanced approaches in developing both local and global solutions to climate and biodiversity crises.

All scenarios depict a future of rural and marine areas in the context of extreme weather events and ecological crises, all be it with different intensities. Social developments, instead, range from major social confrontations to more collaborative and inclusive practices. Their policy implications include, among others, the need to address major risks of patchy land use that hamper the sufficient size of ecosystems and diminish resilience. The scenarios also touch upon integrated spatial planning of urban, rural and marine areas, and how the effective use of spaces can benefit from the further extension of user rights. Future research could explore if and how land ownership models in some rural areas could be replaced or complemented with public ownership and user rights. Furthermore, policy implications include a need for balancing sustainability with food affordability and security in different modalities of agriculture and aquaculture. The challenges of climate and biodiversity crises addressed by the scenarios suggest that balanced approaches are needed in developing both local and global solutions.

This brief is the result of one of eight Deep Dive Foresight Studies in the project 'European R&I Foresight and Public Engagement for Horizon Europe' conducted by the Foresight on Demand' consortium for the European Commission. During the spring of 2023, an expert team identified factors of change and organised two scenario and one policy implications workshops also engaging experts from academia, business and public administration around Europe. The process was also supported by discussions in the Horizon Europe Foresight Network. Further information and room for interactive discussion are provided on the project's website: www.futures4europe.eu

1 Introduction

The Earth's surface is a dynamic union of its solid crust, its atmosphere, its hydrosphere, and its biosphere, all acting in concert. The immense social and technological evolution of the Anthropocene continues transforming the Earth's surface and its dynamics through extensive (mis-)use of its resources, both on the land and in the sea (See Figures 1 & 2).

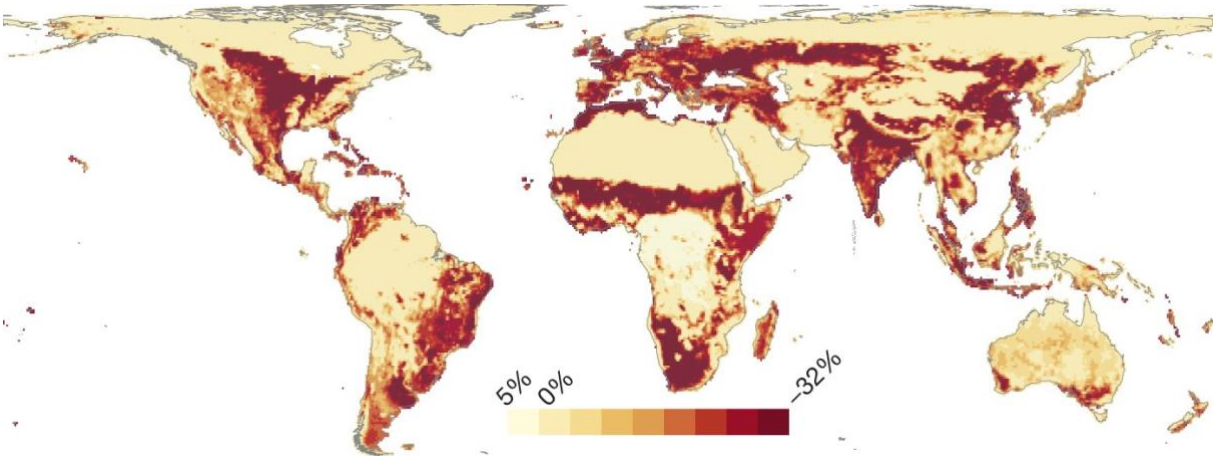

Figure 1. Cumulative net change in local biodiversity caused by land use and related pressures by 2000[1]

[1] The map depicts net local changes to date in biodiverity richness since AD 1500. Newbold, T., Hudson, L., Hill, S. et al. Global effects of land use on local terrestrial biodiversity. Nature 520, 45–50 (2015). https://doi.org/10.1038/nature14324

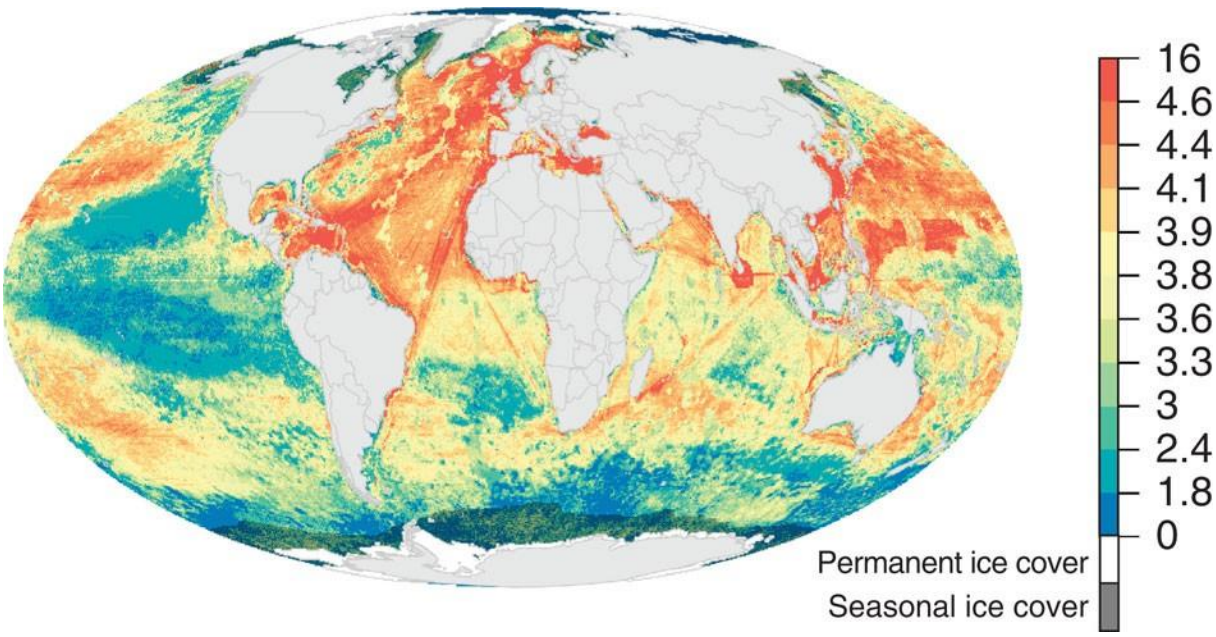

Figure 2. Cumulative human impact on marine ecosystems as of 2013[2]

This policy brief explores how in Europe such broadly unsustainable patterns could evolve and how they could be managed toward 2050. We consider alternative, also promising, futures in the land and seas with implications for human and planetary well-being. The exploration of alternative futures may provide ideas on how current practices could be changed. While many challenges are global, we focus geographically on Europe and look toward 2050, with emphasis on regimes of stewardship of land and sea, and we address the role of ownership, access and use rights in rural areas (cities excluded), multiple uses of spaces (both land and sea), biodiversity, food (both aquaculture, fisheries and agriculture), energy (use of renewables), raw materials (mining etc.), carbon removal and storage, as well as climate mitigation and adaptation. From the scenario work, we derive implications for European research and innovation policy.

2 Alternative futures on rural and marine Europe 2050

This foresight[3] **work develops alternative scenarios**, narratives of the future (written in the present tense, as if we were already in the future). The key factors of change (see Annex I) identified helped us define four dichotomic dimensions to provide a structure for the scenario work. We chose to focus on dimensions that capture how the natural resources are used in rural and marine areas, what type of activities take place and how society at large functions and is governed in the following dimensions:

[2] This map depicts changes in global cumulative human impacts on the ocean from 2008 to 2013. It shows the absolute change in cumulative impact scores for every single patch of ocean. The highest score in either period was 11.1, so increases of two to three points represent substantial changes. Source: Halpern, B., Frazier, M., Potapenko, J. et al. Spatial and temporal changes in cumulative human impacts on the world's ocean. Nat Commun 6, 7615 (2015). https://doi.org/10.1038/ncomms8615

[3] Foresight uses several methods that complement each other and help rendering outcomes thought-provoking, even presenting surprising ideas about future developments that are amenable for further elaboration by policymakers and other stakeholders. While the objective is to have a balanced representation of diverse stakeholder views, in practice the process depends on the context in time and the subsequent readiness of stakeholders to engage. Efforts were made to cover the wider possible range of diverse perspectives, although the results chiefly rely on the contributions of those actively involved in the process. Using a structured dialogue, the process offered opportunities for mutual learning among participants to explore together possible futures and reflect on related policy implications. The scenarios are not predictions of the likely future, but rather depict possible, contrasted images of the future to expand one's own span and to unveil possible risks and opportunities.

Key dimensions for the scenarios
Dimension 1: Economic model *-Growth and Global Trade* International trade is booming, and EU member states compete in global markets and between them. European farmers and fishermen suffer from competition with low-priced imports (except for typical local produce). Government interventions with the markets are minimal and focused on optimising market performance, e.g., addressing externalities with tradable pollution rights. *+Post-growth and Autonomous Europe* There is still trade between continents, but European self-sufficiency among the Member States is secured in terms of essential food and products. Growth is no longer the key policy goal but alternative models to markets and private property are developed, including collective governance solutions and access and use rights to land and other resources.
Dimension 2. Environment and production *-Intensive mass production* Rural and marine economies and planning are focused on the efficient intensive production of energy, food and other raw materials using all technological means to maximise the production and benefit from the economies of scale. Efforts are made to minimize the negative environmental impacts with end-of-pipe solutions (e.g. wastewater treatment, filters and catalysers) and more efficient production to produce more from less. *+Regenerative multifunctional production* Rural and marine economies and planning are focused on restoring the ecosystem carrying capacities and on the regenerative production of energy, food and other raw materials using all means to have the lowest possible impact on biodiversity. Efforts are made to maximise the positive environmental impacts with regenerative solutions (e.g. land and marine permaculture). Biodiversity is addressed especially by adapting economic and human activities to nature rather than defining specific conservation areas.
Dimension 3. Trust society *-Low trust society* People have little trust in persons beyond their immediate circle. They do not trust the government and other institutions, and vote for extremist parties or singular-topic parties that challenge existing structures. Society is divided into groups that envy and distrust each other. Political decision-making is strongly hindered, leading to poor legislation. People evade taxes, local policymakers refuse to implement (poor) legislation, fraud and corruption are rampant. *+High trust society* People trust each other and their governments and other institutions. **Trusted modes of democratic representation are well** established, and parties can afford to look for solutions for the longer term and the greater good. People trust each other, leading to a high willingness to pay taxes, abide the law, and show solidarity (within and across member states). Governments can go quite far in exercising control over (the geographical spread of) various economic activities.
Dimension 4: Governance *-Weak democracy and centralised government* The autocratic centralised governments rule and have absolute control and decision-making power in matters of state. Autocrat's power structures are supported by oligarchs to govern the state. *+Strong democracy and participatory governance* Further to representative democracy, the deliberative democracy adopts elements of both consensus decision-making and majority rule. Participatory governance enables citizens to engage actively in public affairs such as citizens' assemblies, townhall meetings, participatory budgets and referenda.

While the dimensions are used to identify dominant features, alternative practices are also considered in the scenarios though always in relation to the dominant features. The scenarios are defined by selecting one of the two extremes of each dimension. In Figure 3 the dimensions are presented in pairs in vertical and horizontal access. The dimensions of the economic model and the production and environment provide the large axes in which we inserted the second axes of governance and trust society are inserted. Thus, this creates a structure of 16 alternative futures for scenario development. In the scenario workshops, the participants discussed them all and agreed on developing four scenarios as indicated.

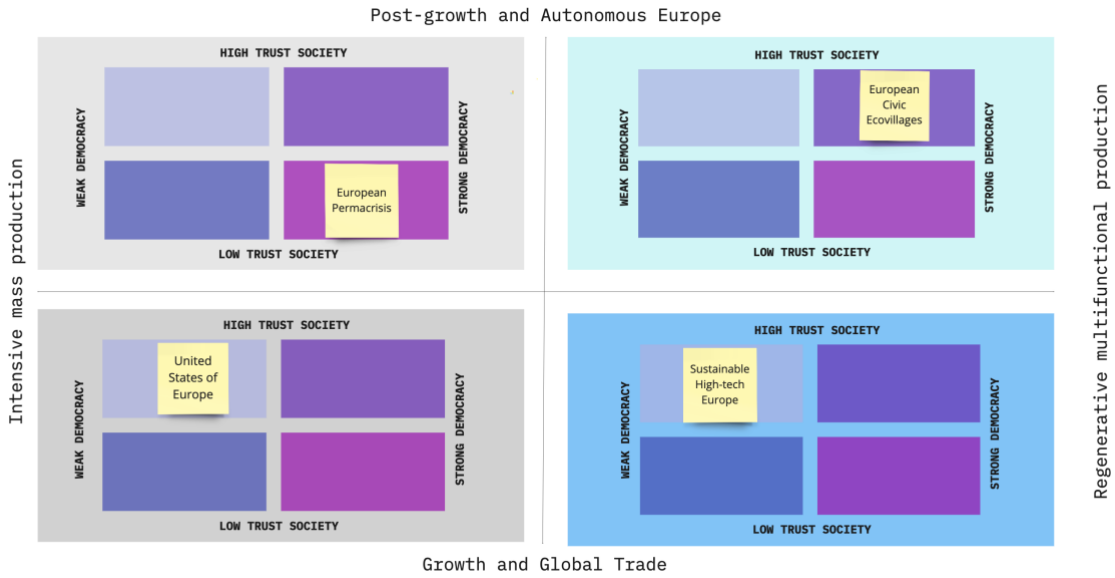

Figure 3. Positioning of the four scenarios in the common scenario structure.

The scenarios depict the future of rural and marine areas in a context of increasing uncertainties and socio-ecological crises, social confrontations, and extreme weather events, in which sustainable use of rural and marine areas will require changes in consumption and economic patterns. Even if rural and marine innovations in Europe are featured in all the scenarios, they face varying barriers and thus also scale up differently. While the development of incremental improvements in existing practices (e.g. in energy, transport, agriculture or fisheries) are often justified because of their easy deployment, they can also paralyse the transition toward radically different solutions. The broad spectrum of possible solutions for the rural and marine economy provides the baseline for transitions, for instance from meat to more plant-based or from fish to molluscs-based diets or from fossil fuels to electricity/battery/hydrogen-based transport and energy systems. To explore alternative trajectories of future developments on land and sea, the following sections illustrate each of the 4 scenarios, discussing their main elements: Economy and technology; Demographics, lifestyles and values; Governance; Environment.

2.1 Scenario A – European Civic Ecovillages

Key dimensions

Post-growth and Autonomous Europe
Regenerative and Multifunctional Production
Strong democracy and participatory governance
High Trust Society

In brief

It is 2050. In the face of the intensifying climate emergency and the concomitant frequent crises, ensuring survival for current and future generations has become the prime policy goal in Europe. Europe strives to achieve self-sufficiency in terms of essential products, food, materials and energy. The economy is predominantly characterised by cooperative prosumption [4] patterns. The locally oriented caring economy is nurturing quality of life

Figure 4. European Civic Ecovillage. AI generated, Picsart.

[4] Prosumption refers to a process where a consumer takes over some of the activities previously performed by a producer, usually by directly involving themselves in the design and production of various goods or services - https://encyclopedia.pub/entry/38133

across the whole territory. The health of ecosystems has become a top priority across all policy fields. Spatial planning is looking at land and marine areas in an integrated manner. It is focused on restoring ecosystems through multifunctional regenerative production practices that nourish biodiversity both on land and at sea. Extractive practices that are harming ecosystems are abandoned or at least limited to absolute necessity and a multitude of regenerative agroecology practices are tested and implemented across Europe. Many ecosystems have gradually recovered. The shift towards an inclusive well-being economy has come with the widespread adoption of deliberative democracy approaches across the EU. Citizen councils and assemblies are widely established to develop and implement bespoke well-being policies in each local context. People trust each other and their governments.

Economy and technology

De-globalised Europe has established an economic system in which gross domestic product (GDP) growth was traded off for the inclusiveness, resilience and sustainability of agri-food, socioeconomic and environmental systems (FAO 2022)[5]. In their economic activities, people nurse the life-carrying capacities of the ecological cycles.[6] Much of the economy is characterised by locally oriented commons-based peer production within cooperatives and similar types of non-market-driven partnerships that generate value for their communities by harnessing renewable energy and the capacity of socio-ecological systems. Companies have installed representation mechanisms for the interests of nature and future generations into their corporate governance. Resilient technology solutions that use a minimum of energy and resources and can be easily maintained are highly popular (known as Res-Tech rather than low-tech) and featured in many university programs. The quest for good ways of organising such mutually beneficial multi-species value creation and of fostering prosumption communities is also at the centre of economics curricula. The overall level of economic activities has gone down in the last twenty years, but most people pursue some kind of non-market caring activities and help nourish relationships – activities which have come to be viewed as prime contributions to value creation.

As land has become central to cooperative economics, rural and coastal areas are no longer at the periphery but at the very centre of the stage – in a way they have become Europe's most critical economic hubs where vital economic sustainable primary production of food and energy and caring of ecosystems are taking place.

Inequality has been reined in by drastic regulation of tax avoidance, speculation and excessive consumption which left behind several stranded assets, particularly in fossil fuel-based industries. Progressive fiscal systems are de facto limiting disproportionate wealth accumulation and many super-rich people have left Europe. The average income and savings account is rather low, but community services such as health, education and social security are available for all and working hours are low.

The Energy system is supported by a decentralised web of clean Res-Tech solutions powering households and production processes. The transport sector is fully decarbonised, private car ownership is largely abandoned, and people move by public transport, bicycles of all types or occasionally shared vehicles. Renewable energy is increasingly produced offshore and stored and distributed with hydrogen solutions. On land also pumped hydro and sand- and salt-based thermal energy storage solutions are common, and often managed by prosumer communities. Communities combine solar installations with infrastructures and regenerative land use practices wherever possible.

[5] Scenario Trading off for Sustainability (TOS). Awareness, education, social commitment, sense of responsibility and participation triggered new power relationships, and shifted the development paradigm in most countries. Short-term gross domestic product (GDP) growth and immediate final consumption were traded off for inclusiveness, resilience and sustainability of agrifood, socioeconomic and environmental systems. FAO. (2022). Drivers and triggers for transformation. The future of food and agriculture: no. 3. Food and Agriculture Organization of the United Nations. http://www.fao.org/3/cc0959en/cc0959en.pdf https://doi.org/10.4060/cc0959en

[6] Bollier, D. (2017). Re-imagining Value: Insights from the Care Economy, Commons, Cyberspace and Nature. https://www.boell.de/sites/default/files/re-imagining-value-report.pdf

Diversification of farms agroecology[7] has become the production standard in Europe. Food prices reflect the contribution of ecosystem services as damage to ecosystems can no longer be externalised. Meat and fish consumption has plummeted, and meat and dairy farming are limited to only a few areas where practices are in line with the regenerative cycles of socio-ecological systems, for instance, poultry combined with agroforestry and permaculture. Sustainable supply chain models around alternative food systems are widely established with marketing channels focusing on local initiatives. Sustainable food innovations as well as permaculture both on land and sea flourish, and the use of synthetic agrochemicals is virtually eliminated (FAO 2022). Territorial management policies foster landscape multifunctionality and diversification across marine and land ecosystems.[8]

The EU has also carefully reduced resource flows into and out of its region. Food exports are only a fraction of what they were in the 2020s as agricultural space is needed for domestic production and productivity per hectare is lower, the policy of zero export subsidies has been rigorously sustained[9]. Next to primary food production, land regeneration activities that increase the carbon sequestration of soils (in particular peatlands) and decrease carbon losses while nurturing biodiversity are highly valued, rewarded and pursued by many land-managing communities. Another important source of income and well-being is local, ethical, experience-based, low-emissions eco-tourism.

Demographics, lifestyles and values

As land has become central to cooperative economics more people seek to move from urban towards rural areas and engage in some type of ecosystem caring activity. Rural infrastructures such as fast bicycle lanes, and local and sharing mechanisms are continuously in need of improvement to integrate more active commoners. Unsustainable practices of second homes in the countryside have been abandoned in favour of multifunctional, shared rural homes/housing arrangements. Along with the deepening ties to nature and in the face of scarcities, food-related practices also have a new central position within the social fabric. Several communities have re-invigorated and newly created practices of sharing and celebrating food production and consumption, with the legacy of past generations being highly valued along with insights from communities around the world especially from warmer climates. Migrants escaping climate and other crises from all over the world are actively involved in the prosumption communities. Some migrant groups with farming backgrounds play a major pioneering role in the agroecological paradigm shift. As people trust each other in bottom-up civil initiatives, social innovation and democratic participation strive.

Value is seen as something that emerges naturally as living entities interact (relational values). The contribution of more than human entities to value creation is highly recognised. Care labour is highly appreciated and is shared between many members of communities. People value clean air and water, trusting relationships, safe public space, affordable housing, public infrastructures and mutually caring relationships more than material wealth and possession of commodities (see the Economy section). Ethics literacy is high – with animals ever more recognized as community members, meat and fish consumption has plunged while innovations around plant-based diets are surging. Relations between humans and nature elements have deepened through a rich diversity of spiritual, religious and philosophical practices often inspired by youth and alternative voices including from indigenous communities outside the EU. Empathy skills towards other beings are developed in learning experiences from an early age on, sometimes supported by advanced science and technologies. Both marine and inland ecosystems are highly valued. Due to the intense involvement of most people in prosumption activities and the high transparency of the local production infrastructure, trust in products is high.

[7] Agroecology is the application of ecological concepts and principals in farming. Agroecology promotes farming practices that; Mitigate climate change - reducing emissions, recycling resources and prioritising local supply chains. https://www.soilassociation.org/causes-campaigns/a-ten-year-transition-to-agroecology/what-is-agroecology/#:~:text=Agroecology%20is%20the%20application%20of,and%20prioritising%20local%20supply%20chains

[8] cf. Scenario B2 in Rega, C., Helming, J., & Paracchini, M. L. (2019). Environmentalism and localism in agricultural and land-use policies can maintain food production while supporting biodiversity. Findings from simulations of contrasting scenarios in the EU. Land Use Policy, 87, 103986. https://doi.org/10.1016/j.landusepol.2019.05.005

[9] In 2015, WTO members agreed to abolish export subsidies. Developed countries had to do so with immediate effect (with some transitional periods until the end of 2020), developing countries by the end of 2023 and least developed countries by the end of 2030. https://agriculture.ec.europa.eu/international/agricultural-trade/wto-and-eu-agriculture_en

Governance

A highly developed deliberative democracy has adopted elements of both consensus decision-making and majority rule. Citizens engage actively in public affairs through various means such as citizens' assemblies, town hall meetings, participatory budgets and referenda. Central common resources such as water basins and the like are governed by "user committees". Spatial planning is looking at land and marine areas in an integrated manner. Intergenerational justice is integrated as a core principle in all decision-making processes so long-term impacts are always considered. The voting age has been lowered and in some very long-term decisions, young people's voices are considered with enhanced weight. School curricula are designed to empower citizens from an early age on, to engage in participatory decision-making: competencies for deliberation, collaboration and foresight are taught early on. Participatory governance extends into the working life where, even in those few bodies that are not cooperatively managed, deliberative mechanisms characterise decision-making. Central common resources such as water basins and the like are governed by "user committees" where also more than human beings are represented (see the Economy section).

Because of the highly localised governance, one of the major challenges is how to decide over large-scale projects that are potentially beneficial for society such as large-scale renewable energy facilities and pylons for electricity infrastructure, and several conflicting interests are at stake. These projects require extensive often time-consuming deliberation processes. Nevertheless, conflicts over renewable energy installations on coastal land and sea are often solved through Integrated coastal zone management (ICZM) and Marine spatial planning (MSP) as both processes have considerably gained authority. Moreover, community ownership of rural and marine energy solutions helps to realise otherwise controversial projects.

Environment

Climate change has driven a shift in European population patterns. Some areas that have been suffering from heat, drought and pollution are losing inhabitants and active farms. Throughout Europe, people have been displaced due to climate change impacts. On the one hand, people migrate from regions with intolerable heat and water scarcity, at the same time the sea level rise has forced the abandonment of several coastal areas towards countries with more moderate temperatures in the North of Europe. Mechanisms to compensate rehoused people and displaced businesses are established.

Solutions to increase resilience against flooding and sea level rise, as well as frequent shock events, are researched and debated intensively. At the same time efforts to combat climate change are dominating all policies and in particular territorial management practices. The key challenge is to find solutions that combine mitigation and adaptation benefits.

The shift towards more environmentally friendly and multifunctional primary food production has come with substantial co-benefits for ecosystems and human health. Agrochemical fertilizers were replaced with alternatives from organic sources and even waste streams[10] together with the abandonment of pesticides this has alleviated several aspects of ecosystem depletion. The production of chemical and persistent organic pollutants has been halted. Accordingly, anoxic zones are reduced, and deoxygenation of the oceans is now a minor issue.

Climate change mitigating agroecological LULUCF (land use, land use change and forestry) activities have helped to minimise GHG emissions from soil in the EU. Scientific methods for estimating the climate impacts of different land management practices, as well as their impact on nature restoration have been developed and are in widespread use across Europe.[11] Several of the LULUCF pioneering communities engage in participatory scientific research to better understand and promote ecosystem flourishing. In particular, they strive to maximise co-benefits and balance trade-offs between carbon storage, food production and biodiversity nurturing. Special care is taken of organic soils, including peat

[10] cf e.g. project Circular Agronomics https://www.circularagronomics.eu/
[11] Soil carbon (2022). EEA briefing: no. 15/2022. Publications Office of the European Union.

lands to preserve their carbon storage capacity. This has maximised co-benefits for biodiversity and water quality and at the same time increased crop yields.[12] Regenerative agriculture focusing on the environment and biodiversity has also halted and reversed soil degradation and improved the water storage capacity of soils while maintaining food production capacity. [13] The increasing evapotranspiration of soil moisture due to climate change and land degradation has been halted and excess nitrogen is substantially decreased. Thanks to the control of pollution and the right-sharing of water resources, there are only a few instances of water shortages and groundwater is of good quality. As a result of these major joint efforts of communities and governments across Europe land and coastal ecosystems are gradually recovering. Biodiversity is regenerating and numbers of pollination insects are picking up.

The EU has adopted a territory-sharing strategy pursued locally that entails the preservation of low-intensity marine and agroecosystems, including high nature-value farmland' and combined it with territory-sparing approaches[14,15]. Overall, the agriculturally used area is slightly reduced but energy output from land is increased.[16] In some places with also previously strong primary food production the activities have been intensified in other areas, these activities were reduced or even abandoned.

Around 10% of European countries' territories are designated as high protection areas, including terrestrial and marine areas, where no human activities are permitted, leading to restoring and rewilding these areas. 80% of the territories are designated for sustainable and regenerative practices. The remaining 10% are still in intensive rather unsustainable use to due path dependencies related to existing infrastructure. Overall, this has had a positive impact on biodiversity. The biodiversity crisis is slowing down due to the generalisation of sustainable practices, but some species still suffer from human interactions and climate change and continue to be endangered. Europe is doing little to solve global climate and biodiversity crises.

R&I policy implications

Within this scenario, we could envisage major parts of the European research budget being managed at the regional and local levels and a variety of universities and research organisations across Europe focusing on their specific areas of activities on rural land-sea interaction. Within such a context, the EU added value would be mainly promoting of sharing of results and solutions across Europe.

The table below lists some future developments depicted in the scenario; and proposes possible R&I policy implications either to attain or to hinder such developments depending on their perceived desirability by policymakers.

Future developments in the scenario	R&I policy implications
Economy and technology	
Regenerative circular production systems	Promote research into regenerative production with positive criteria (maximising positive impacts rather than minimising negative impacts). Such systems can often - in small scale - be managed by local communities supported by robust technologies. Research could include investigating conditions for successful scaling up of solutions.

[12] Soil carbon. (2022). EEA briefing: no. 15/2022. Publications Office of the European Union.
[13] Rega, C., Helming, J., & Paracchini, M. L. (2019). Environmentalism and localism in agricultural and land-use policies can maintain food production while supporting biodiversity. Findings from simulations of contrasting scenarios in the EU. Land Use Policy, 87, 103986. https://doi.org/10.1016/j.landusepol.2019.05.005
[14] Grass, I., Batáry, P., & Tscharntke, T. (2021). Combining land-sparing and land-sharing in European landscapes. In Advances in Ecological Research. The Future of Agricultural Landscapes, Part II (Vol. 64, pp. 251–303). Elsevier. https://doi.org/10.1016/bs.aecr.2020.09.002
[15] Soil carbon (2022). EEA briefing: no. 15/2022. Publications Office of the European Union.
[16] Rega, C., Helming, J., & Paracchini, M. L. (2019). Environmentalism and localism in agricultural and land-use policies can maintain food production while supporting biodiversity. Findings from simulations of contrasting scenarios in the EU. Land Use Policy, 87, 103986. https://doi.org/10.1016/j.landusepol.2019.05.005

Communities combine solar installations with infrastructures and regenerative land use practices wherever possible, the European Solar Test Installation (ESTI) of the JRC has become a key reference point.	Open up large-scale research infrastructure facilities to community-based participatory research.
On land also pumped hydro and sand and salt -based thermal energy storage solutions are common, often managed by prosumer communities.	Research into alternative energy storage solutions and their management and governance, among others pumped hydro and sand and salt -based thermal energy storage solutions.
Resilient technology solutions that use a minimum of energy and resources and can be easily maintained are highly popular (known as Res-Tech rather than low-tech) and subject to many university programs	Consider in the design of programs also experimentation of autonomous resilient technologise and frugal innovations managed by local communities in Europe and developing countries.
Demographics, lifestyles and values	
Several communities have re-invigorated and newly created practices of sharing and celebrating food production and consumption, legacy of past generations is highly valued as are insights from communities around the world especially from warmer climates.	Social innovation programmes that build on cultural practices of sustainable human/nature interaction especially around food and land-related (cultural studies, philosophy, psychology etc.)
Governance	
A highly developed deliberative democracy has adopted elements of both consensus decision-making and majority rule. Citizens engage actively in public affairs through various means.	Programmes for the development and piloting o new methods for deliberative democracy Deliberative democracy skills & competencies building Participatory decision making for large scale projects
Transboundary commons management rules for use of land, fish stocks and deep sea including more than humans as active stakeholders	Research into multi-species justice theory and commons management and the development of regulatory sandboxes for experimentation.
Several of the LULUCF pioneering communities engage in participatory scientific research to better understand and promote ecosystem flourishing.	Infrastructure for participatory community research, citizen science toolkits etc. required
Environment	
Diversification of farms agroecology has become the primary production standard in Europe. Communities strive to maximise co-benefits and balance trade-offs between carbon storage, food production and biodiversity nurturing Scientifically sound methods for estimating the climate impacts of different territorial management practices, as well as their impact on nature restoration	Life cycle and biodiversity balance of various land uses Circular Agronomics[17] Shared research infrastructure for mutual learning and scaling up good practices
Societies are heavily affected by severe climate change impacts and strive to establish resilience. A highly localised governance structure which does not allow for large scale solutions.	Research and experimentation of multi-level governance practices to increase resilience against flooding and sea level rise as well as frequent shock events and at the same time support climate change mitigation. This also opens up a more general question on how a funding system could look like that still comprises an EU Framework Programme, but builds on decentralised structures and decisions.

[17] https://www.circularagronomics.eu/

2.2 Scenario B – Sustainable High-tech Europe

Key dimensions
Growth and Global Trade
Regenerative and Multifunctional Production
Weak democracy
High Trust Society

Figure 5. Sustainable High-tech Europe. AI-generated, Picsart.

In brief

It is 2050, and the European Union does not exist anymore. The cause for the disintegration was the failure of "soft" democracy in the mitigation of all environmental challenges such as climate change, biodiversity erosion, the increase of pollution, and in autonomy in all vital goods and resources. Therefore, EU citizens became aware of the necessity for rapid and radical change and turned their trust to strong national and local leaders, resulting in a high-trust society coupled with autocratic regimes. The end of the EU meant the end of Common Policies such as Agriculture, Fisheries and Trade & other EU programmes and funds, end of financial transfers for solidarity, cohesion, CAP etc. ap in economic growth across and within countries widened. Regimes of weak or pseudo democracies specialised to compete in global markets, are heavily dependent on global trade of key commodities such as food, energy and raw materials such as minerals and metals. Other major geopolitical blocks have also vanished, and countries have looked for the UN system as well as the World Trade Organisation (WTO) to provide common guidance, though major tensions remain on regulating global trade and the balance between developed and developing countries. In Europe, the management of rural, coastal and marine areas is aligned with national plans under the guidance of the UN bodies promoting sustainable use of resources, conservation of biodiversity and ecosystem services. In Europe, countries have their national specialisation strategies, some with global leadership in regenerative and multi-functional high-tech solutions for energy, aquaculture and agriculture, but others struggle to well position themselves in the global markets.

Economy and technology

The economic structure is based on international trade rules set up by the World Trade Organisation (WTO). In rural, coastal and marine areas, local economies are defined by national economic plans that are themselves elaborated according to the UN decisions and guidance. Some regions and their businesses manage to meet the requirements and develop green solutions for global markets, especially around regenerative and circular agriculture and aquaculture concepts as well as renewable energy and other low-carbon technologies, for instance, marine windfarms and marine hydraulic energy are booming, offering European companies export opportunities around these solutions. Food production is organised along value chains from producers to retailers that are embedded in the global market and most profit is going to big international companies which manage the commodities. On the other hand, many regions and countries struggle to position themselves in the global markets and are caught in the vicious cycle of trade imbalance and growing debt.

The UN lead sophisticated system of earth observation and data recording and monitoring is developed all over the world through the Internet of Things to support stringent agreements for countries to comply. Complex networks of sensors from satellites to underwater observatories are developed. Modelling helps decision-makers to anticipate natural disasters (mega-fires, floods, pest pandemics, heat waves…) and reduce the risks of water and food shortage. However, not all countries can afford to participate and benefit from these systems. The carbon market is regulated at the UN level. All carbon emissions,

especially linked with global trade, are regulated and taxed. Blue carbon and green carbon credits are managed by a global system.

Maritime traffic is planned and controlled by the International Maritime Organisation (IMO) and by international economic interests. Almost all international maritime traffic is on products (commodities) and high-tech solutions and work-related travel. Due to their high environmental impacts, cruise ships have practically gone, research expeditions are planned by the Intergovernmental Oceanographic Commission (IOC) under UN exploration plans. Deep-sea mining has been authorized in some sites for specific minerals needed for renewable energy purposes. All deep-sea mining is managed by the International Seabed Authority (ISA), including in the Exclusive Economic Zones (EEZ). On land some underground mines for rare earth minerals are also in operation, but open-pit mines have been largely closed and repurposed.

Businesses in Europe are global leaders in sustainable aquaculture and agriculture solutions. Industrial fisheries have been limited to carrying capacities, but aquaculture is booming, sustainable fish production remains in open seas where the ecosystem has a strong carrying capacity, also some aquaculture produces seaweed and shellfish, especially molluscs. Local fisheries and aquaculture production, instead, are artisanal and limited to local traditional consumption.

Agriculture follows the same patterns with automated high-density multifunctional and regenerative concentrated production, e.g. agrivoltaics, aquaponics and agroforestry, linked to the global markets, and local low-density ecosystem-based agriculture, such as permaculture, for local communities. There has been a major shift in food production and consumption from beef to poultry, fish and molluscs, and especially to plant-based diets for healthy and affordable food and environmental sustainability. Breakthroughs with diverse application strategies to implement such changes have cemented the European global leadership in the regenerative food industry, especially in terms of know-how and high-value solutions, to meet the global demand and UN regulations.

With the end of the Common Agricultural Policy, the related EU funds have dried out and cannot be redistributed across Europe. Furthermore, much of the capital is concentrated in the hands of European multinational corporations that largely control global commodities. Banks are associated with these companies and governments are under the influence of powerful lobbies. Economic power is concentrated in dense urban areas where all decision-makers, either governmental or from the private sector, are clustered, supplying these urban areas with the necessary resources and offering recreation and tourism options.

Demographics, lifestyles and values

In general, inhabitants trust their autocratic governments and accept the limitation of their individual rights and living driven by national specialisation plans for global markets. While the plans and lifestyles differ, there are some common characteristics, too. In rural and coastal areas people live in close relationship with the natural environment.

Transport is largely limited to work and freight, and international tourism has become rare, leading to an important decrease in GHG emissions. The specialisation plans work for some countries, but not for all. Tensions rise between those with work, income or growth and those without. Some countries can afford to offer universal income, where people work fewer hours, and hunger and poverty are eradicated, but others do not enjoy such opportunities.

Further tensions arise between Governments and multinational corporations, who exert a growing control over global trade and show little respect for national specialisation strategies. The elite controlling global trade, both the staff of international companies and civil servants of the governments, is living in relative isolation. The latest trend is for the companies to establish themselves in floating cities of tax paradises in international waters that grant them extra-territorial financial regimes and loose regulatory conditions. The world is divided: on the one hand, the people living in the rural and coastal areas, close to natural systems, and on the other the elite living in cities disconnected from nature.

People living in rural and coastal areas have a close relationship with nature but cannot really manage the natural resources due to the lack of authority and competencies which are centralized. Although anticipated by the government thanks to the high technology monitoring systems, climate change has induced extreme events and sea level rise is impacting some coastal populations. The climate refugee issue has become important in some territories and is often neglected by central governments.

Governance

Formally, most European countries have some form of representative democracy in place. However, in practice democratic institutions are weak, and elections are manipulated and sometimes all but rigged. Still, in these election-based autocracies, people let their governments operate when environmental, social and economic development.
Participatory processes engaging citizens in policies are rare and when in place they serve to create the perception of participation in shaping plans and to build trust in the government.

The lack of European coordination among countries has led to major tensions over the cross-border water basin, rivers and migration policy. Also, heated competition dominates and there is little sharing of good initiatives. Countries even compete for aid assistance to the countries suffering from major natural disasters, notably in Latin America and Africa, which has become a priority to reduce climate refugees and other migration. National autocratic governments are keen to follow the guidance of UN organisations when they help legitimise the government plans and actions.

National specialisation plans are elaborated by national governments, under the UN guidance, and considering several indexes such as the import-export ratio, the nature conservation index, and the citizen happiness index, amongst others. For example, national food production, including agriculture, fisheries and aquaculture is following the decisions made by the FAO (Food and Agriculture Organisation), in relation to decisions of the Convention on Biological Diversity (CBD) and the UN program on Environment (UNEP). Science is coordinated at the national level according to the global research plans elaborated at the UN level. Large research centres are often located near the cities.

The ocean is managed under the overall framework of the UN Convention on the Law of the Sea (UNCLOS) and its implementing agreements, such as the Fish Stock Agreement for fisheries and the Biodiversity Beyond National Jurisdiction (BBNJ) agreement for biodiversity conservation. The BBNJ treaty is extended to the national Exclusive Economic Zones (EEZ). A robust coordination mechanism is in place between the ocean-related agreements under UNCLOS.

Coastal communities have still some rights to local resources, and as for agriculture, fisheries and aquaculture are managed locally within national food production plans. Marine Spatial Planning (MSP) processes are implemented locally under the control of the government. The coastal areas are managed in an integrated way at the local level. But despite national plans, there is no implementation of MSP at the broader scale because coordination is lacking at the regional level. This leads to the incapacity to tackle climate change impacts that are not manageable at the local scale.

Environment

Nature in Europe has benefited from the national governments following UN decisions. An ecosystem approach to fisheries is implemented and overfishing does no longer happen. Fish production is regulated by the national authorities according to FAO guidance based on UN agreements. Fisheries quotas are implemented under production plans. Businesses in Europe are providing relevant fish for world consumption, for example, salmon, sardines and some benthic resources from the North Sea, and notably molluscs such as bivalves from aquaculture.

Illegal Unregulated and Unreported fisheries (IUU) are decreasing also globally thanks to improvements in high-level control technologies such as ship tracking systems using satellite data or radar. Fisheries regulations are enforced by regional fisheries management organisations (RFMOs) operating within the

global rules. Climate change mitigation and adaptation measures have been implemented with mixed results in European countries following the United Nations Framework Convention on Climate Change (UNFCCC) decisions.

Global warming is felt throughout and across the World. Even if has slowed down, projections are alarming. Sea level rise is happening as predicted and measures are in place for sometimes building new artificial coastal defence infrastructures but most commonly opening the coastline to natural restoration, thus accepting to lose coastal territories. Measures are defined at the national level according to the decisions made at the UN level. Brackish water aquaculture is developing as the sea level rise provides new areas for extensive rearing of various species such as seabass, seabream, mullet, shrimps, etc. But in many cases, sea level rise consequences are highly taxing, leading to a climate refugee crisis also in Europe. Resilience is an objective of the national governments following UN guidance, but in many cases, local communities have difficulties adapting and coping with the new climate conditions.

The biodiversity loss crisis is devastating, but it is finally slowing down due to conservation measures implemented nationally according to the CBD and UNEP agreements and implementing programmes. Around 10% of European territories are designated as high protection areas, including terrestrial and marine areas, where no human activities are permitted, leading to restoring and rewilding these areas. 60% of the territories are designated as protected areas with 50% allowed sustainable use activities. About 10% are still subjected to intensive, rather unsustainable use. The remaining 20 % are managed intensively but with sustainable practices.

R&I policy implications

Within this scenario, we could envisage the research budgets at the European level being decreased radically. Countries have their own national research budgets and infrastructure developments and the lack of cooperation between the countries creates major overlaps. National universities and research organisations focus on specific areas of activities on rural land-sea interaction.

The table below lists some future developments depicted in the scenario; and proposes possible R&I policy implications either to attain or to hinder such developments depending on their perceived desirability by policymakers.

Future developments in the scenario	R&I policy implications
Economy and technology	
Regenerative production practices follow the ecosystem approach principles	Programmes for experimentation and scaling up of regenerative production practices
Ecosystem approach to fisheries is implemented	Programmes for research, experimentation and scaling up of fisheries aligned with the ecosystem carrying capacity.
Some European countries are global providers of renewable energy technologies, especially offshore wind and wave energy plants.	Technological development and experimentation programmes for competitive offshore renewable energy engaging also third countries
Carbon markets (emission credits/permits) are globally developed, European countries engage actively in the development and implementation.	Research on the extension of carbon credits markets to new productive sectors and also a wide set of carbon sequestration options. The permits could thus provide wider incentives across the economy for green energy transition.
Primary production is developed in European countries for providing global commodities (selected products)	Experimentation and impact assessment on high density, close circuit, vertical agriculture and large scale aquaponics for mass production in agriculture and aquaculture.
Maritime traffic is dedicated to transportation of global commodities and high tech solutions.	Programmes for technological development of Low carbon emission ships for merchandises transportation (decarbonisation of maritime traffic)
Demographics, lifestyles and values	
Climate refugees and migrations are a big problem generating social disturbance in some regions.	To mitigate: at the EU level search for synergies and complementarieis across Member States to develop and experiment and scale up a wide range of climate solutions To adapt: at the EU level promote and monitor national plans for research and innovation to anticipate possible climate refugee and migration patterns and to understand what regions will be affected more and to establish priority

	programmes for more gradual adaptation, e.g. land-use planning.
Governance	
60% of the territories are designated as protected areas with sustainable use activities[18]	Coordination across Member States and third countries to ensure sufficient size nad number of protected areas. Experimentation of governance models benefiting all stakeholders including the nature for areas combing nature conservation and sustainable economic activities.
The coastal areas are managed in an integrated way at the local level. But despite national plans, there is no implementation of MSP at broader scale because coordination is lacking at regional level. This leads to incapacity to tackle climate change impacts that are not manageable on a local scale.	Experimentation and scaling up of good practices for vertical coordination of multi-level governance for resilience, climate mitigation and adaptation.
Environment	
60% of the territories are designated as protected areas with sustainable use activities	Research into ecosystem recovery and development of monitoring infrastructure in Europe and globally
Illegal fisheries are eradicated	The development of mechanisms for ship tracking in all oceans and seas based on space and other monitoring technologies
A sophisticated system of observation and data recording and monitoring is developed all over the world through the internet of things	Technological development of Earth observation system / connected networks
The environment is highly monitored in order to address and minimize environmental risks, especially linked to climate change consequences.	Technological development of all kinds of earth observation tools and systems from satellites to underwater drones.

2.3 Scenario C – United States of Europe

Key dimensions

Growth and Global Trade
Mass production
Weak democracy
High Trust Society

In brief

By 2050 the citizens and governments of Europe have collectively agreed that an ever-closer union keeps Europe competitive in a world dominated by geo-political power blocks. Centrally coordinated planned interventions based on geographical orographic systems rather than the tyranny of national boundaries help also manage the needs of European citizens and critical environmental infrastructure. A strong 'United States of Europe' can shape rural and marine environments to meet the needs of wider society. The marine and rural areas are, especially, places of primary production and consumption. Intensive vertical farming, for example, takes place within the urban environment where the facilities to manage pollution more effectively are more concentrated and consumption is near. The rural and marine environments are managed as a collective integrated space delivering not just food but many of the ecosystem services valued and required by urban society. Certain shocks to the system, war, and famine, have highlighted the need for greater cooperation and a more unified decision-making structure to meet the needs and aspirations of European citizens. The ability of Europe to recover from the shock has emphasised the need for more autocratic, rational and

[18] For calculations on the size of protected areas, 'Safe and just Earth system boundaries', https://www.nature.com/articles/s41586-023-06083-8

centralised decision making which has widespread support and trust from the citizens. Isolationist and independent nation-states were too small to compete on a global stage. Therefore, Europe as an entity has evolved to exercise a high degree of power and trust through top-down decision-making within Europe. Europe is an active and powerful global player in trade and sustainability agenda (ecoefficient land use, carbon offsetting and spaces for renewal energy and intensive areas for food production), thanks to the leadership of 'Brussels' through centralised decision-making widely accepted by society.

Economy and technology

The economy is centrally planned, but is in practice a mixed economy, with state aid being used to incentivise the private sector to deliver societal goals and services. Inflation is generally low. Over time long-term investment markets gain in maturity, with slower rates of return for eco-system services, including stacking multifunctionality, (e.g., blue and green carbon, flood alleviation clean air, clean water etc). There has been a substantial disinvestment in all activities related to fossil fuels and indeed compensation is being sought from those deemed to have contributed to the climate change emergency.

The marine and rural environments have become a patchwork of different uses and functions. In some areas high-intensity agricultural practices including, for example, precision farming is facilitated by technological development. Here AI is used to ensure that the spaces are used most efficiently and effectively to produce staple food requirements for the urban populations. Within the marine environment, similar approaches are used to maximise production in selected areas, through the designation of areas for aquaculture both in the sea and along the coast, areas to produce blue energy and other forms of highly technological blue economy. In the rural areas, also (semi) closed recirculating aquaculture systems are competitive producing rainbow trout, for instance, for global markets.

Within the areas of intensive production large-scale multinational corporations increasingly are the key actors. It is an open question whether these are state-led or private-sector-led activities although there is a measure of reciprocity in ensuring that the basic needs of urban areas, in terms of both food and energy, are being met at an affordable price. Both in rural areas and within the sea, these intensive production areas are counterbalanced with protected areas accounting for 50% of the land and sea space.

Europe is open to the world and there is considerable trade between fewer but large trading blocs providing a basis to agree on a global approach to the global commons. Europe is beginning to move beyond net zero and this is providing trading opportunities with the rest of the world. The challenges of climate change are being addressed through technological advancements in carbon capture and storage combined with the very widespread deployment of renewable energy solutions both in marine and rural areas. There is an effective European grid which seamlessly transfers power around the continent and Europe has become self-sufficient in power generation largely dependent on rural and marine spaces. Critical resources can be mined or sequestrated with limited environmental impacts. Nevertheless, continuing impacts of climate change and sea level rise are being felt most acutely at the coast where policies of "protect at all costs" are combined with natural realignment. As a result, some communities' displacement becomes more common with policies in place and space allocated specifically to deal with this eventuality.

Demographics, lifestyles and values

Urban Europeans' consumption for leisure and recreation is mainly directed to rural and coastal areas. There is considerable land abandonment, both within coastal and rural communities. With the former, some natural realignment becomes a more acceptable way of managing sea level rise. In rural areas, marginal agricultural land is abandoned and instead is proactively managed to deliver ecosystem

services (carbon sequestration, managing water - flow and quality - and biodiversity net gain). Land-sea interactions at all scales are properly recognised and the role of flows between the land and the sea in terms of pollution and the importance of the flow of goods and services (e.g. food, energy, trade), is fully recognised and high-value is awarded to the role that the marine and rural areas play in servicing the needs of a highly urbanised society.

The landscape and seascape become a mosaic of intensively used spaces, combined with more extensive land uses. Large areas of rural and marine spaces are designated as natural protection areas, and some are left to regenerate naturally. In others, large enterprises intervene to preserve and protect culturally important landscapes adopting principles of land sparing, where the predominant functionality used is leisure and tourism activities. Thus, less intensively used rural marine and coastal areas are often spaces for leisure and recreation and despite a trend for rural and coastal depopulation, especially amongst the younger elements of the community, these areas become refuges for early retirees and those seeking a quiet regenerative experience, with the growth of second and holiday homes. Within many rural and coastal communities (which are not urbanised) dwelling patterns are fluid in places where the service functions are largely delivered by migrant workers.

Governance

Within this mosaic of patterns of rural land use and marine use, the role of spatial planning as a normative mechanism to allocate space for different uses becomes more important. Indeed, the space - whether land or sea – is increasingly envisaged as an integrated European territory without national boundaries. Interesting questions arise as to how these management practices operate in relation to third parties, especially those with shared sea basins within enclosed seas.

Within this framework, centralised decision-making, and an increasing role of spatial planning to control and regulate territorial space become more acceptable. Land and sea become more integrated single European space for spatial planning purposes. Strong environmental regulation is also in place, whether in terms of pollution control or the designation of areas for special protection. The rule of law is widely accepted and is in the common interest, and the designations outlined above are rigorously implemented through strict enforcement mechanisms, which are widely regarded as helping to effectively deliver societal goals following a period of unprecedented shock. This governance framework is replicated around the world and larger trading blocs effectively manage global systems. There is a high degree of trust in European technocrats, in sharing a common vision and making rational decisions about the best use of space. Ideas of land ownership, especially in the rural areas are replaced with a view of user rights, learning from the old marine practices, with the state granting user rights in certain areas or through the designation of protected areas, excluding or revoking previously existing user rights. There is a high degree of trust and to deal with functional spaces. The tyranny of national and regional space gives way to the widely understood need for a greater role for a centralised entrepreneurial government which sits above states and can take a longer-term integrated view of orographic systems.

Environment

Prioritising environmental sustainability, living within environmental limits and the need to restore nature are accepted norms at a European scale. New markets for carbon capture and storage have emerged. This pays for, including carbon offsetting whether on land or within the sea, thus allowing for substantial investment in certain parts of the marine and rural environment and the use of technological solutions such as ocean alkalinization. The rural and marine areas become a mosaic of different uses with a combination of intensively used space for primary production, especially precision farming and closed-looped aquaculture, and/or extensive reforestation and highly designated protection areas. Natural rewilding becomes key, both on land and within the sea and at the interface. Intensive production practices have detrimental impacts locally on the land and dispersed in water

systems, but overall, the quality of the environment has improved, when measured in terms of biodiversity and reforestation, especially at a European scale. With stricter environmental controls of intensive agricultural production, pollution to water courses is reduced and it has less impact on surface water runoff eventually on seas and groundwater aquifers.

Protected areas cover around 60 % of land and sea. Strict or highly protected areas are reaching 50 %, and the other 10% are managed for sustainability, but the large parts of the territory (land and sea) are not protected since they are devoted to intensive production and industrial development. The biodiversity crisis is far from reined in, as the conservation measures are still too weak and dispersed with no overall coherent planning.

R&I policy implications

Within this scenario, we could envisage the European research budget being increased substantially as what were previously national budgets become more focused and consolidated. Former member states still have research budgets, but these address more local matters. A smaller number of larger European elite Universities or research organisations focus on specific areas of activities on rural land-sea interaction. The table below lists some future developments depicted in the scenario; and proposes possible R&I policy implications either to attain or to hinder such developments depending on their perceived desirability by policymakers.

Future developments in the scenario	R&I policy implications
Economy and technology	
New approaches to infrastructure needs allows water supply systems, energy flows and to be much more central planned, based on some agreed perspective of individual need	Research on integrated planning of new infrastructure in an early stage, based on an agreed level of service provision for all European citizens.
New technology allows for more efficient primary production of food in a more intense manner, with the inputs being more carefully managed within a circular economy to ensure that there are limited damaging externalities. Emphasis placed on ensuring that inputs (fertilisers/pesticides etc) and outputs from primary production can be managed within a relatively closed system.	R&I policy implications combine technological developments in existing production facilities and there can be better compliance with environmental regulations. For instance, within these lines, industrial R&D programmes could aim at compliance with environmental regulation.
Demographics, lifestyles and values	
On a global scale, the climate emergency stimulates **increasing** global populations movements with Europe as a destination of choice	To help policymakers to anticipate migration impacts R&I is needed to model the changing demographics within Europe, not just in terms of numbers but also in terms of the impacts on the resources needed to sustain these communities to these new migration streams.
There is an increased societal understanding of the role for managing rural and urban areas based on drainage basins to provide greater societal resilience – whether in terms of mitigating the effects of climate change or by proactively taking steps to enhance biodiversity.	Regional cross-national R&I infrastructure and programmes could be established and aligned with drainage basins for the proper management of ecosystem services.
Governance	
There is greater acceptance of the need for integrated territorial planning aligned with drainage basins of regions for the proper management of ecosystem services. There are changing notions of user rights to space, whether in the land or in the sea. These user rights are increasingly acquired through state approval processes.	Develop technologies, techniques and systems to support integrated territorial planning. The R&I policy in connection to policies responsible of land and sea use could develop regulatory sandboxes for use right experimentation and integrating public concerns and social sciences in these efforts.
Planning across land and sea with an emphasis on thinking about uses on a wider river catchment/sea basin basis enables strategic adaptive thinking to take place as to which areas may become more marginal for human activities and which areas could become more productive.	Research on how the planning process need to change and what are the needs and values attached to this need, and subsequently experimentation in view of a more rational and collective use of space.
Environment	
The rural and marine environments are critical for building resilience and adapting to the climate and biodiversity emergencies.	R&I experimentation on climate mitigation and adaption practices and subsequent scaling up.

2.4 Scenario D – European Permacrisis

Key dimensions

Post-growth and Autonomous Europe
Intensive Mass Production
Deliberative democracy and participatory governance
Low Trust Society

In brief

This scenario sketches Europe with a history of economic turmoil, with a population and political system fraught with distrust and a lack of firm decisions to solve the pattern of crises. People connect to and trust their peers and others in their 'bubble'; others are distrusted. The economic degrowth leads to self-sufficiency efforts for energy, materials and food. To support local industries, tariffs are applied for most imports, especially carbon-intensive products.

Figure 6. European Permacrisis. AI-generated, Picsart.

The political arena is scattered and characterized by many small single-issue protest parties. National governments feel they have no mandate to take firm decisions. Laws are issued, but their quality and resources to implement them vary. Due to the weak position of politicians, companies influence political decisions. The weak economy leads to low rates of innovation, and the R&I that takes place is applied and financed by the companies to ensure their market position. For agriculture, it has resulted in more precision agriculture and other ways to reduce losses of nutrients and water use. The lack of competition with food providers from other parts of the world allows to use more sustainable inputs.

Economy and technology

It is 2050 and the idea of the world is a global village has passed: Europe cannot rely anymore on global trade partners, and self-sufficiency for energy, materials, and food is high on the political agenda. Trade agreements are not renewed, and tariffs are applied for most imports, especially carbon-intensive products. Internal trade still takes place, but economies hardly grow, and the constant risk of recession keeps the rate of investments low. Large companies secure their own innovations, but these generally only contribute to meeting the immediate desires of consumers rather than to the wider positive societal and environmental impacts.

Because of the EU's self-sufficiency ambition and the protection of the European market, food producers can ask fairly good prices for their produce also affecting food affordability. Imports of feed with heavy tariffs, however, are also more expensive, so margins on intensive livestock breeding remain small. Negative externalities of farming and fishing are to a modest extent combated with technological fixes. Investments in incremental technologies, however, increase the socio-technical lock-in of farms and fisheries. Especially farms in areas with multiple environmental problems discover that the technology they invested in only solved one single problem, while it has decreased the resilience of farms when having to deal with other problems as well. Hence, farms in these areas go bankrupt, and land abandonment in 'environmentally challenged' regions is rife.

The need for alternative energy is perhaps not as pressing as in the high-growth scenarios but striving for self-sufficiency increases the need for more renewable energy projects as well as mining activities for the extraction of rare materials. The same applies to the need for renewables in construction materials: not that many houses are being built, but the import restrictions of sand and gravel as well as the need to emit less carbon push the production of timber and bio-based insulation material. Water

retention basins are also an emerging phenomenon to secure more water during summer and to prevent flooding during heavy storms.

In areas that are not particularly interesting for farming but with other value propositions such as landscape attractiveness, vicinity of the coast, and good accessibility, other kinds of rural economies emerge. As society is very fragmented, it is not possible to identify one common denominator. Coastal Mediterranean areas are colonized by rich pensioners in their gated resorts and communities, and areas with cheap land and abandoned villages are populated by groups of people trying to escape modern life. Remote, mountainous areas are claimed by nature restoration parties, and the rural areas near the larger cities are inhabited by people working in the cities. All these communities, suffer from social confrontations, occasionally even devastated by mobs.

Demographics, lifestyles and values

Lack of trust is prevailing. People tend to only interact with those that have a similar view, background and lifestyle. Segregation is strong and the political arena is characterized by single-issue, protest parties. The parties in government are very reluctant to take firm decisions, as they are afraid to lose voters. Solidarity is low, tax evasion is high, and all other kinds of fraud are common. Large companies, who are generally resented for making profits (presumably) at the expense of the people and the environment, benefit from the absence of strong top-down legislation and use their power to influence political decisions.

The lack of political action, in combination with the strong, successful lobby of large companies, increases frustration among citizens. Many call for a strong government and fail to understand why politicians simply do not resolve issues. They organize themselves using social media, and protest or try to take action. People mostly reach out to others that fit into their 'bubble'. As such, they are susceptible to disinformation and polarization is increased further.

Traditional rural inhabitants resent people living in cities, as these represent 'the elite'. They fiercely defend what they see as traditional rural values: community life, family values, traditions, manual labour, etc. Farmers are regarded as 'the rural heroes', as they represent all these values. However, the rural idyll is also embraced by groups of urbanites. They also see cities as pools of destruction and hope to find a better, 'more natural' life in the countryside. Nevertheless, their idea of agriculture clearly deviates from the actual, industrial agriculture, leading to a clash of cultures. They withdraw into eco-communities and establish eco-villages, not seldom in villages that have largely been abandoned.

The flight to the countryside is not restricted to eco-minded urbanites. There are many other groups of actors that (re)claim, peacefully or not, areas in the countryside for achieving their objectives: nature conservationists, rewilders, solar field entrepreneurs, hunter organizations, carbon sequestration companies, recreation operators, second-home owners, drugs producers, sects, etc. What they have in common is having decided to pursue their own personal ambitions, be they for their well-being or for a larger good. They have lost hope that the government will do 'what is right', or simply see an opportunity to evade regulations that stand between them and their objectives.

Governance

Due to the strongly fragmented political landscape, national governments barely have the mandate to take firm decisions: The electorate is scattered and in virtually all countries protest parties have grown considerably. The generally small political parties lack the critical mass and the human resources to propose high-quality laws and amendments. The governmental bodies that are supposed to check compliance with the law are hardly delivering, as they are fraught with political motives rather than juridical ones. The EU parliament manages to issue a few firm laws pertaining to environmental protection but is forced, in the negotiation, to give in to the wish of national governments to be less strict on forbidding state support.

National politicians desperately try to regain voters' trust, for instance by organizing citizen participation in questions surrounding the energy transition, nature protection, and sustainable agriculture. But regardless of their efforts, most people are still not consulted (or are consulted, but still don't feel heard), and this process achieves a counter-productive effect, as rumours are spread that politicians deliberately rely on their circle of cronies. In other attempts to repair trust, politicians propose legislation with an often symbolic or protectionist nature.

As governments are weak, spatial planning is also weak. Anyone with influence and money can buy land and use it the way they see fit. Farmers have a relatively strong position to hold on to land in the more fertile regions but are easily seduced to sell land to any party that is willing to pay a good price. Urban sprawl and landscape cluttering are the result. Furthermore, several of the EU directives have varying local impacts. Due to environmental restrictions, specific areas are no longer attractive for farming. Here agricultural land abandonment takes place.

In the marine environment, fisheries are not sustainably managed as rules are not correctly applied. Fish stocks are declining, and some fisheries have collapsed. The remaining fisheries are struggling to maintain a viable level of production. Aquaculture is developing quickly, and its production now largely exceeds that of the fisheries, but there are many issues, such as legal security for using the public domain, that prevent aquaculture to be sustainable. Ecosystem-based principles are not applied to aquaculture and contamination issues are common.

Environment

In relative terms, intensive farming has become somewhat more sustainable than it used to be at the beginning of this century. R&I has resulted in more precision agriculture and other ways to reduce losses of nutrients and water use. The lack of fierce competition with farms from other parts of the world allows using more sustainable inputs: compost from human faeces for instance. Also, genetically modified cultivars (the EU gave up its resistance to this) have reduced the use of inputs. However, owing to the lack of an integrated approach towards a sustainable countryside, everything that is not captured in strong European laws is going to waste. This concerns, in particular, the general environmental quality. The countryside looks unattractive. Industrialization of farming, in combination with solar farms, fishing ponds, urban sprawl, mining, and other economic activities has led to strong landscape cluttering in agricultural areas. The high level of technology, the further intensification, and the vast monocultures that arise from even further specialization raise concerns regarding their vulnerability to plagues and diseases. In particular, concentrations of livestock raise concerns of zoonosis.

In the areas where intensive farming has withdrawn, the various private initiatives occasionally lead to developments that are favourable from an environmental perspective. In particular, the larger ecosystem restoration projects deliver promising results. Also, some of the alternative farming initiatives result in synergies with agriculture and nature. However, fragmentation is common, and even the favourable developments are negatively affected by this: the ecosystem restoration efforts run afoul for a lack of spatial coherence and severe conflicts between the various organizations about what and how to restore; the promising alternative farming initiatives never manage to reach sufficient critical mass to be a serious alternative for intensive, mainstream agriculture. The patchy rural and marine areas have become vulnerable to ever more frequent extreme weather events; flooding flashes farmland nutrients to delicate coastal ecosystems, sea level rise spoils aquifers; draughts tricker riots, and heavy storms lead to electricity blackouts and road blockages. The recovery from any such crisis tends to take more and more time, especially when they overlap.

Seas are different from land in that no people live there. That makes them the perfect solution for all kinds of NIMBY problems. Wind farms? At sea. Airports? At sea. Large polluting industrial complexes? At sea. It is a relative blessing for marine wildlife that trade is on the decline so that transport using freighters is much less than it used to be. Despite this, marine ecology has suffered considerably from the many new activities at sea. Overfishing is another persistent problem. Because meat has become more expensive (due to a tax on unhealthy products and expensive feed), and because of import tariffs on fish from Asia, the domestic demand for fish is higher than ever. Sustainable fishing strategies appear impossible to implement because the EU cannot come to agreements with e.g. the UK and the northern

African countries about fishing quota. Intensive aquaculture is successful in some sites where environmental conditions are favourable (high currents, relatively deep waters), but it is also having a lot of failures due to contamination. Although still producing a lot, aquaculture does not get to stabilise to a sustainable level of production.

Due to the slow industrial and economic development, in some areas, nature has recovered, but in general there is very little progress in terms of biodiversity conservation. The 2030 biodiversity conservation targets have not been met. There are still around 20% of the national land and seas officially under protection status, but even in such areas, the government suffers the lack of resources to enforce the compliance.

R&I policy implications

Within this scenario, we could envisage the research budgets being decreased substantially and fragmented among numerous actors, each having their interests and goals – much of the public R&I investments are done at the regional and local levels. Many universities and research organisations develop their own income streams leading to an emphasis on their educational programmes, applied research and consulting.

The table below lists some future developments depicted in the scenario; and proposes possible R&I policy implications either to attain or to hinder such developments depending on their perceived desirability by policymakers.

Future developments in the scenario	R&I policy implications
Economy and technology	
Farms in areas with multiple environmental problems discover that the incremental technology they invested in but decreased the resilience of farms to deal with other problems as well.	Research on (escaping from) lock-ins on unsustainable production systems, for instance, the impact of end-of-pipe/process and efficiency technologies R&I on alternative more sustainable and integrated systems and their diffusion Research on the environmental effects of scale of different farming practices
Criminal activities in rural areas take flight because it is fairly easy to operate 'under the radar' in these vast areas of Europe	Develop smart and affordable remote sensing technology in combination with AI to detect potential criminal activities (e.g. temperature, electricity use, vehicle movements, etc.). Investigate how undesirable biases using AI can be avoided and how the privacy issues can be managed
Demographics, lifestyles and values	
The decline of facilities in rural environments forms a divisive issue between rural and urban populations. It feeds resentment amongst rural inhabitants towards 'the elite' living in cities.	R&I on affordable and reliable facilities and services in rural areas R&I on technologies for rural areas conserving their aesthetic appeal.
Governance	
Spatial planning is weak, anyone with influence and money can buy land and use it the way they see fit, often with a negative impact on the environment. Marine spaces are all public with little planning, legal insecurities hamper the development of aquaculture.	Development and experimentation to develop reliable spatial planning that integrate land and sea as a common territorial space for sustainable use to develop and diffuse good practices.
Farmland is increasingly bought by non farmers to develop non farming activities.	Research governance practices of new landownership structures, in cases where the need for public goods justifies a transfer from private to public, or from public to private, landownership.
Environment	
The patchy rural and marine areas with monoculture have become vulnerable to ever more frequent extreme weather events.	R&I programmes to support industrial competitiveness in areas where vulnerabilities may create opportunities for innovation.
There may be many initiatives for ecosystem restoration, but they are not coordinated and may sometimes even conflict.	Investigate the potential synergies and conflicts between restoration projects with different targets to overcome them and develop new solutions.

3 Cross-cutting analysis and R&I policy implications

Each scenario depicts a different future in rural and marine Europe. None of the scenarios features a decisive solution to the global climate and biodiversity crises. Scenario A forcefully targets the resolution of the biodiversity crisis in Europe, by aligning human practices with nature, but provides little support to global climate and biodiversity crises. Scenario B proactively tackles the biodiversity crisis both in Europe and internationally but struggles with the fragmentation of efforts and with scaling up good practices and wider impact to curb the crisis. Scenarios C and D with intensive use of nature reduce biodiversity. Thanks to European-wide coordination Scenario C can protect vast areas with positive impacts to biodiversity, whereas Scenario D struggles with the major fragmentation of conservation efforts and its detrimental impact on biodiversity. Such challenges illustrate the importance of balanced approaches in developing both local and global solutions to climate and biodiversity crises.

The subsequent further cross-cutting analysis pinpoints some threats and opportunities for rural and marine areas in Europe. This may provide a basis for further reflection on the possible role of R&I policy in Europe in the future and serve as inspiration when designing future R&I programmes in Europe.

Economy and technology

- In three of the scenarios **big business** plays a key role in determining what is scaled up but, in parallel, local communities try out solutions. Apart from the rest, in scenario A (European civic ecovillage) both the innovation and deployment are in **local communities**. R&I programmes searching for scale could well benefit from both dynamics.
- All scenarios face the challenge of **balancing sustainability and food affordability and security** in different modalities of agriculture and aquaculture. The advances may well come from integrated approaches that also consider major shifts in diets and production.
- Solving negative externalities of large-scale monoculture continues to be a relevant research stream, for instance via **precision farming (**see scenario C). Still, research and development is also needed on alternative farming practices that allow closing the loops and controlling the production, for instance, **vertical farming, aquaponics** and (semi)-closed recirculating water systems for aquaculture highlighted in scenarios A and B.
- **Multifunctional use of land and sea** can provide win-win solutions, e.g. aquaponics, agrivoltaics, agroforestry, marine permaculture and floating PV panels, and thus strike a balance between different needs. This often represents major changes in practices; thus, the **local (prosumer) communities** need to be part of the process for their insights and buy-in (especially prevalent in scenarios A and B).

Demographics, lifestyles and values

- All the scenarios depict the future of rural and marine areas related to socio-ecological crises. Further research could aim to strengthen civic resilience. Could measures to increase crisis preparedness among individual and local communities be developed?
- Research on the future of rural and marine areas and **demographic changes** could be useful given the above-mentioned uncertainties. For instance, water scarcity or other climate-related crises may induce major migrations also in Europe.
- Fragmentation in rural and marine communities and planning can become a major concern. Even if good practices exist, fragmentation hampers their scaling up, while coordination may breed thriving active local communities. R&I programmes could provide opportunities for further mapping, showcasing and enhancing the mutual learning between good practices of local community-based organisations.
- The livelihood of rural communities is to a greater or lesser degree entangled with urben spaces and how their inhabitants value rural communities. R&I can be involved in pursuing

better connections between urban and rural, such as online farmers' markets, remote working and the future evolution of rural infrastructure.

Governance

- The diffusion of innovations is crucial for sustainable rural and marine areas. In this respect, and where the framework conditions favour planning and encourage investment, it should be easier to scale up. R&I policy should aim to improve framework conditions, including the **predictability** of government R&I programmes.
- Integrated **spatial planning of urban and rural areas is a key issue**. Space, whether land or sea, could be envisaged as an integrated territory defined by orography and natural geography, e.g. drainage basins, regional watersheds and coastal seabed (see the figure below), rather than socio-political boundaries. R&I policy instruments could be demarcated with such an integrated approach in mind; joint cross-national research institutes and infrastructure could be established.
- The use of spaces could benefit from **extending user rights.** For instance, land ownership models in some rural areas could be replaced or complemented with public ownership and user rights, learning from the practices within the marine sector, with the state granting user rights in certain areas or through the designation of protected areas, excluding or revoking user rights previously in force. Experimentation, e.g. in regulatory sandboxes, could also rely on public sector innovation processes. Before experimentation in regulatory sandboxes can take place, there is a need for R&I efforts to detail how the user rights could be extended in different conditions and what would be the impacts to different stakeholders.
- The scenarios related to diverse democratic practices. Policy labs on **citizen participation in decisions on rural and marine areas** could serve to connect citizens with these areas. Direct involvement of local communities in R&I programmes could be a means to avoid NIMBY effects and ensure their support.

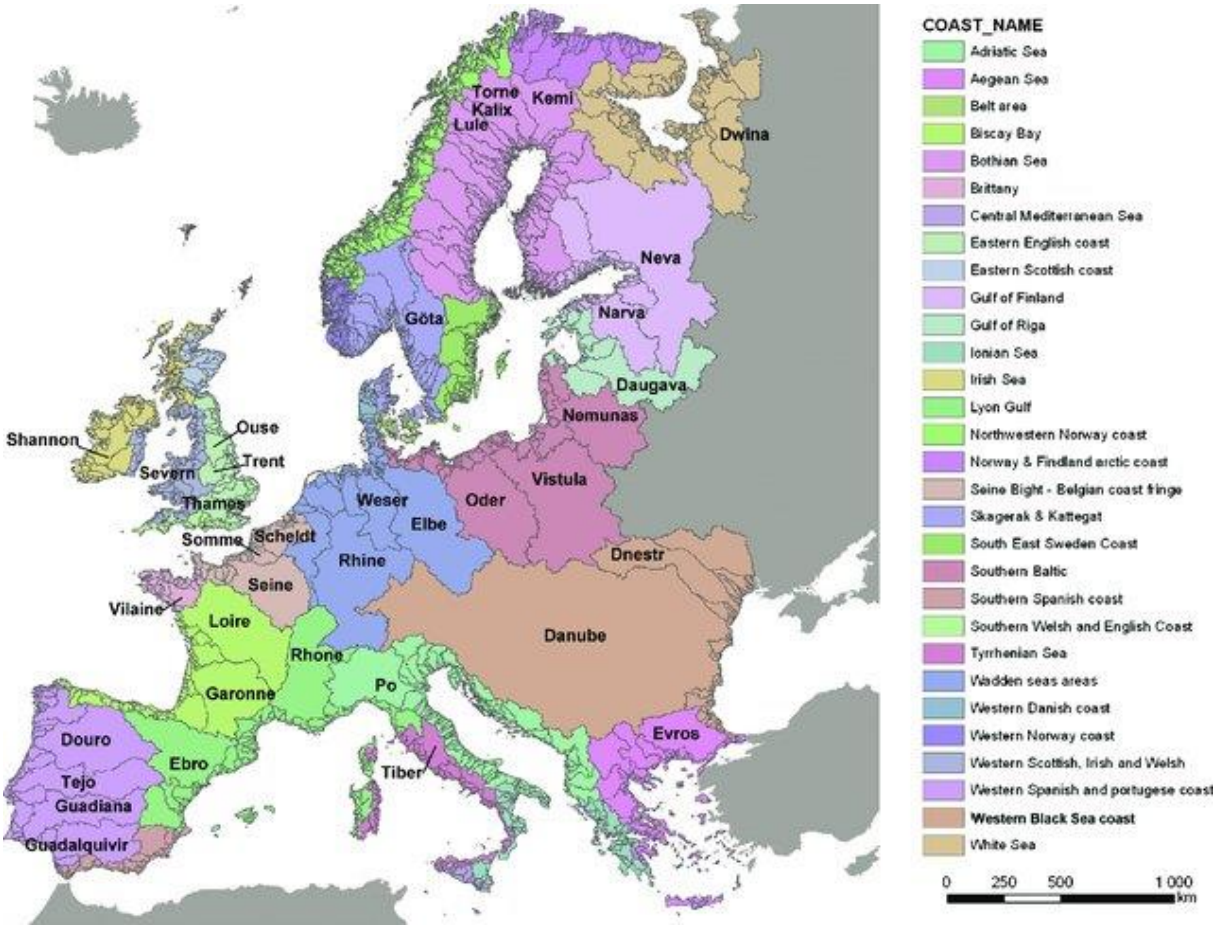

Figure. Major regional watersheds in Europe and their receiving coastal marine systems.[19]

Environment

- There are **major risks in a patchy land and sea** use that segments ecosystems and breaks up ecological corridors, diminishing the biodiversity and the resilience of nature. R&I programmes on integrated spatial planning of land and sea, also including for in-land waters, can pave the way towards more resilient, more circular water use and integrated management for addressing tensions between alternative uses of land and sea and in parallel ensuring sufficient size of protected areas[20].
- The effects of monoculture and economic specialisation reducing societal and ecological resilience could be mitigated by concentrating them to limited **high-intensity production** areas and by scaling up **regenerative alternative practices.** Both these directions could be promoted via R&I instruments to experiment and learn about ecological and socio-economic implications.
- Technology could play an important role in monitoring nature to understand it and the impacts of human actions. Multidisciplinary research on resilience in rural and marine areas could help increase preparedness, including integrated planning supported with **biodiversity monitoring** combining in-situ sensors and remote space technologies and advances in data analytics (AI) and construction of digital twins of integrated spaces for developing reliable future

[19] Copyright: Penny J. Johnes. https://www.researchgate.net/publication/236671571_Nitrogen_flows_from_European_regional_watersheds_to_coastal_marine_waters/figures?lo=1

[20] For calculations on the size of protected areas, 'Safe and just Earth system boundaries', https://www.nature.com/articles/s41586-023-06083-8

projections. Also, advances in guidance and toolkits could serve to improve the reliability of **citizen science**.

- Regenerative ecosystem-based approaches and practices could strengthen **synergies** between nature restoration and production activities. R&I programmes could experiment scaling up such practices, and with how nature restoration and rewilding could be further connected to climate mitigation and climate adaptation.

Annexe I: Factors of change

While the main scenario dimensions provided the structure for the scenario work, the factors of change provide ideas on possible future developments and issues to be considered in the scenarios. In the workshops, participants will **relate and adapt the factors** to the dimensions of each scenario and **propose new factors and issues** to be addressed in a scenario. We have prepared a non-exhaustive collection of factors of change by scanning the web for recent developments and using the earlier foresight project results. The factors are categorised as follows:

- Environment
- Demographics, lifestyles and values
- Economy
- Governance
- Practices and technologies

It is highly recommended that you familiarise yourself with the factors to be ready to use and adapt them to specific scenarios in the workshops.

3.5 Environment

Title	Description including possible future projections	References
Declining biodiversity due to human activity	The currently massive threats to marine and land biodiversity linked to human activities will grow even further. Over-exploitation remains the key threat, resulting in major disruptions of ecosystem functionning (e.g. eutrophication, acidification, and desiccation of ecosystems. Climate change in combination with land use change is likely to further contribute to deterioration, for instance by droughts (natural and human-induced) and reduction and fragmentation of habitats. The decline and, in some cases, extinction of marine or land organisms will damage the long-term health of the oceans or land and their services, such as carbon sequestration and food provision.	https://www.sciencedaily.com/releases/2019/10/191001132650.htm
Climate Change	Multifaceted phenomenon with progressive impacts on food production, land use, policies and lifestyles Drivers: industrialisation - fossil economy - overconsumption - mechanisation and industrialisation of farming Impacts: more demand for (rural) raw materials (e.g. biomasses) that are ecological, affordable and safe. Primary productivity will go up in temperate Europe, but extreme events are likely to undo the gains, be it in a highly erratic manner (unpredictable, strong losses in distinct areas and periods). Nature is likely to suffer strongly from droughts, whereby entire forests may collapse, especially those consisting of non-drought resistant monocultures. Carbon credits will become increasingly scarce, having a significant impact on prices of artificial fertilizer, greenhouse production in cooler regions, transport costs, and peat protection measures. Rural housing will increase - prospects for non-mainstream farms will improve, e z. local, ecological, energy ~ scarcity for usable land will increase	https://ruraltrends.eu/list-of-all-trend-cards/
Ocean temperature rising	Ocean warming of 1.2–3.2°C, depending on emissions, is projected by 2100. Evidence shows that this causes mass fish migration towards the pole, decline in cold-water fish species and coral bleaching. Marine heatwaves are predicted to increase dramatically in frequency and magnitude as a consequence of global warming. Surface and subsurface	https://www.sciencedirect.com/science/article/pii/S0303243418301016

	Chlorophyll-a concentration variation (effect). Continued global warming and associated ice decline have consequent impacts on the polar cold engines that fuel the great ocean conveyor and that regulate the global climate.	
Sea level rise	A combination of melting polar ice and water expansion due to warming led to a global sea level rise of around 20 cm between 1901 and 2010. This is projected to continue rising. Current estimates suggest a further rise of 0.25–1 m by 2100 depending on emissions. Sea level rise has impact on coastal erosion and flooding. There is a need to consider coastal protection and countermeasures to sea level rise. For marine systems, impacts are expected to vary geographically.	https://www.euronews.com/2019/09/25/watch-live-ipcc-releases-key-report-on-world-s-oceans-and-ice-sheets
Increasing shortages of water and poor chemical status of groundwater	The effects of droughts and floods, the increasing levels of human pressure in cities due to urban sprawl, the emergence of new contaminants and the overexploitation of water for agricultural purposes will, among other factors, probably exacerbate the risk of water shortages in the years to come. Agriculture is the main cause of groundwater's poor chemical status, as it leads to diffuse pollution from nitrates, phosphates, and pesticides. There is pollution, that is caused by wastewater disposal by industry, insufficient sewage water treatment, and pesticides and fertilizers used in agriculture. And there is salinization, which is caused by mismanagement in irrigation but also by saline seepage in the coastal zones.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Acidification of oceans and waters	Ocean acidification is the ongoing decrease in the pH of the Earth's oceans, caused by the uptake of carbon dioxide (CO2) from the atmosphere. Dissolution of CO2 in seawater produces a weak acid that has decreased surface ocean pH by ca. 0.1 below pre-industrial levels, and an additional 0.3-0.4 decline is expected by the year 2100. The sea has absorbed very large amounts of CO2. This decreases the pH levels of sea water, making it less alkaline, threatening the biological processes of many marine species. Shellfish, whose ability to form shells is reduced by acidification, are particularly vulnerable.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand. https://www.iucn.org/sites/default/files/2022-07/ocean_acidification_issues_brief.pdf
Increasing evapotranspiration of soil moisture due to climate change	Climate change could impact evapotranspiration of the soil. This will increase the frequency of agricultural droughts and increase the irrigation water demand, while decreasing the flow in rivers and creeks, which are the dominant sources of irrigation.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Land degradation	A significant proportion of managed and natural ecosystems are degrading and face further risk from climate change and biodiversity loss. Population growth coupled with urbanisation is putting soils under pressure, while agricultural intensification is making soils more prone to erosion. Soil loss by erosion is the main cause of soil degradation in the Mediterranean region. Soil deterioration by contamination is an important issue in central, western and northern Europe.	https://www.eea.europa.eu/publications/92-9157-202-0/page306.html#:~:text=Sealing%20of%20soil%20surfaces%20due,degradation%20in%20the%20Mediterranean%20region.
Conflicts overrenewable energy	Energy systems are undergoing a significant shift to renewable energy (RE). To date, the surface area required for RE systems is greater than that for non-RE systems,	Warnke & Könnölä. 2022. Land use futures, Science,

installations on land and sea	exacerbating existing environmental policy challenges, from increasing land competition to visual impacts. Wind energy, both on sea and land, has special implications. Solar panels, too. How these are combined with other uses of land etc. can play an important role. Biofuels require a lot of land, with crops like palm oil and soy encroaching upon forests and grasslands but also competing with food production as farmers switch to more profitable energy crops (Kovacs 2015).	Technology and Innovation for Ecosystem Performance – Accelerating Sustainability Transitions, Foresight on Demand.
Bioaccumulation of plastics due to increased plastic use	Plastic does not decompose, instead breaking down into ever smaller pieces; microplastic is accumulating both in soil and on the sea, even in tap water. Plastic in the ocean is projected to treble between 2015 and 2025. The full effects are not understood, but there is growing evidence of plastic harming sea creatures and restricting their movement, as well as polluting beaches. There are also evidences that plastic debris in the ocean are vectors for many organisms as well as pathogens and therefore contribute to the transportation of species outside of their natural distribution and spread of diseases.	https://www.reddit.com/r/Futurology/comments/dy7z28/plastic_waste_converted_back_to_oil/ Frontiers | Plastic as a Vector of Dispersion for Marine Species With Invasive Potential. A Review (frontiersin.org)
De-oxygenation of seas, threatening ecosystems	De-oxygenation: a combination of nutrient-rich pollutants entering the sea, and rising sea temperatures is increasing the prevalence of excessive blooms of algae that can both smother intertidal habitats and also deplete underwater oxygen levels. This can have severe consequences for marine biodiversity and fisheries, causing population declines, reduced reproduction and reduction of suitable habitat.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand. https://www.iucn.org/sites/default/files/2022-07/ocean_deoxygenation_issues_brief_-_final.pdf
Increase of chemical and persistent organic pollutants	Chemical pollution is an ongoing issue, as pollutants can persist in the oceans for decades after their use is restricted by legislation. The list of chemicals deemed to be persistent organic pollutants (POPs) continues to grow.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Nitrogen and phosphate pollution due to fertilizer runoff	Much of the nitrogen and phosphate that are applied as fertilizers eventually enters rivers, lakes, groundwater and oceans, fertilizing blooms of algae that deplete oxygen, creating hypoxic or dead zones where little can survive.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Overfishing	The issue of overfishing is very important for countries that rely on fisheries but also for degrading ecosystems and boost biodiversity loss when it is not the direct cause of biodiversity loss. Fisheries loss threatens to destabilise countries that rely on them. According to FAO, food supply will have to increase 60% by 2050 to meet the demands of seafood production. Severe	https://www.researchgate.net/profile/Gabriella_Caruso/publication/284625083_Fishery_Wastes_and_By-products_A_Resour

	impacts to ocean ecosystems are illustrated by 33 per cent of fish stocks being classified as overexploited and greater than 55 per cent of ocean area being subject to industrial fishing.	ce_to_Be_Valorised/links/565584c908ae1ef9297723b1/Fishery-Wastes-and-By-products-A-Resource-to-Be-Valorised.pdf https://www.nrdc.org/bio/lauren-kubiak/marine-biodiversity-dangerous-decline-finds-new-report
Pandemics and Epidemics	More frequent or more dangerous epidemic diseases would affect whole societies and could increase preference for safe rural living environments. This will have high impact on areas with strong livestock concentrations. Drivers: coronavirus pandemic, pandemics - scarcity of natural resources - environmental degradation. Impacts: entry of new inhabitants to rural areas -demand for ecological, affordable and safe rural housing will increase - more demand for local, regional or domestic food - more demand for local (rural) products and services.	https://ruraltrends.eu/list-of-all-trend-cards/

3.6 Demographics, lifestyles and values

Title	Description including possible future projections	References
Integration of Immigrants	Integration of immigrant to local labour market and civic society may provide an opportunity to enhhance inclusive social fabric and y to make a societal contribution Drivers: migration patterns - solidarity, equality - conflicts and governance failures Impacts: more equal and inclusive social fabric - diversification of rural economies - increase in the socio-cultural diversity - entry of new inhabitants to rural areas - migration from urban to rural areas will increase	https://ruraltrends.eu/list-of-all-trend-cards/
Urbanisation and (sub)urban sprawl	Increase of cities in terms of people and land use will make 'rural' more rare and valuable but challenge rural economy and autonomy. The average age of the population is quite high and increasing in many rural regions. This contributes to the decline of the rural population, due to the agglomeration of rural areas that become urban areas but also partly due to young people moving to cities.	https://ruraltrends.eu/list-of-all-trend-cards/
A growing population living close to the sea	With a growing proportion living close to the sea and depending on a number of oceanic services, our societies will become increasingly vulnerable to natural oceanic disasters.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Remote Work	Working from outside of a traditional office environment e.g. from home, co-working spaces or in rural hubs, which saves commuting time and emissions has become much	https://ruraltrends.eu/list-of-all-trend-cards/

	more common during the pandemics. This trend is expected to continue.	
Rural Housing and Rural Second Homes	Influx of pensioners and urban dwellers with second homes to rural areas will increase demand for land for residential purposes. Areas attractive for second homes (e.g. the Algarve) see a sharp increase in housing prices, outcompeting the local people, resulting in a deterioration of the social fabric.	https://ruraltrends.eu/list-of-all-trend-cards/
Natural and Cultural Heritage	Natural and cultural heritage carry on valuable environments, fabrics and artefacts from the past which contribute to identity and attractiveness of places. heritage is lost because young people leave for cities and at the same time there is gowing awareness and attempts to preserve it. The conservation of rural heritage enhance local, regional or rural identity or brand, valorise existing rural sites, villages and heritage and help maintain reproduction of social capital.	https://ruraltrends.eu/list-of-all-trend-cards/
Anti-consumerism movements	Anti-consumerism to consume less goods is rising as a response to societies based on individual material gain, here-and-now-thinking. The driving force of modern industrial civilization has been individual material gain, accepted as legitimate and even praised worthy on the grounds that private vices yield public benefits. It's long been understood that a society that is based on this principle will destroy itself in time.	Könnölä et al. 2022. Deep Dive 'Climate Change, Research, and Innovation: Radical Options from Social Change to Geoengineering' philosopher Noam Chomsky: Quote by Noam Chomsky: "Modern industrial civilization has developed wi..." (goodreads.com)
Environmental Values	People wish to reduce environmental degradation, to safeguard earth systems and to improve the status of the environment. Drivers: climate change - environmental degradation, pollution and risks - ecological awareness - urbanisation Impacts: mitigation of climate change - better resourced and targeted local policies - increase of environmental conservation and/or reduction of degradation - prospects for non-mainstream farms will improve.	https://ruraltrends.eu/list-of-all-trend-cards/
Rural Lifestyles increasingly idealized	Rural idyll, space, nature, peace, animals, housing, safety, traditions and communities contribute to social welfare and attract new residents. Rural places and areas get new attractions and effective brands - diversification of rural economies - increase in socio-cultural diversity - growth of local rural economies (incomes, jobs) - migration from urban to rural areas will increase. Risks are that the expectation of the newcomers conflict with the reality of modern rural live. Conflicts between farmers and new inhabitants about noise and smell of intensive farming are frequent in areas where lots of urban newcomers arrived in the countryside.	https://ruraltrends.eu/list-of-all-trend-cards/

Shifts toward sustainable diet	Keep calories in line with health guidelines, meat alternatives, vegetarian/vegan diets.	IPCC. (2021a). Chapter 5: Demand, services and social aspects of mitigation. In Climate Change 2022: Mitigation of Climate Change, https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_Chapter05.pdf
Prosumerism communities	Microgrid energy communities and urban farming communities show way for a larger part of population to engage in not only in consumption but also production of goods and services in their local contexts.	Könnölä et al. 2022. Deep Dive 'Climate Change, Research, and Innovation: Radical Options from Social Change to Geoengineering'
Demonstrations and other forms of civil activism	Making visible discontent and dissatisfaction, even with possible incarceration Occupation and sit-ins: Interrupting the normal order and business as usual. Blockades: Physically stopping access to a project or location Boycotts: Disrupting markets and profits for private sector firms Labour strikes: Mass refusal of employees to work until demands are met Trespassing activism: Challenging property rights and attacking media attention	Sovacool, B. K., & Dunlap, A. (2022). Anarchy, war, or revolt? Radical perspectives for climate protection, insurgency and civil disobedience in a low-carbon era. Energy Research and Social Science, 86(November 2021), 102416. https://doi.org/10.1016/j.erss.2021.102416
Conflicts over offshore drilling and use of resources	Conflicts over offshore drilling and use of resources. For instance, after a long dispute between the EU and Turkey regarding the latter's activities which EU comments as "illegal", EU sanctions against who are involved in offshore drilling activities in the Eastern Mediterranean within Cypriot territorial waters.	https://safety4sea.com/eu-imposes-sanctions-against-turkey/ Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.

3.7 Economy

Title	Description including possible future projections	References
Globalisation pressures	Drivers: globalisation - food demand and supply - network-based governance - international trade rules Impacts: increased export demand for sustainable food products - large farms become more and more dominant, e.g. productivity, exports - mixed farming prospects, positive or negative, depending on the type of farm, business, region etc.	https://ruraltrends.eu/list-of-all-trend-cards/

Diversification Of Rural Economy	Many rural regions have diversified economies and the importance of non-agricultural activities has increased. Drivers: digitalisation - empowerment of services - evolution of specific markets Impacts: diversification of rural economies - growth of rural economies (incomes, jobs) - new or better rural services and/or better access to services - better (rural) employment opportunities for women - migration from urban to rural areas will increase	https://ruraltrends.eu/list-of-all-trend-cards/
Infrastructures, Accessibility and Connectedness of Regions	Availability and quality of roads, railways, water, electricity, telecommunications etc. necessary for settlements and economic activities. Major infrastructure projects are implemented for transport arriving by sea, ports; goods moved railways and highways. Drivers: decline or poor status of public services and infrastructures - rural and regional policies Impacts: new or better rural services and/or better access to services - improved infrastructures - improved access to rural areas and destinations - multi-local lifestyle becomes more common enhancing rural economies.	https://ruraltrends.eu/list-of-all-trend-cards/
New approaches to highly effective use of land and sea	There is a rise of approaches for sustainable and affordable food production c with a highly effective use of land (e.g. vertical farming) and sea (e.g. molluscs farming)n replacing less effective approaches such as cattle raising.	https://ruraltrends.eu/list-of-all-trend-cards/
Growing marine economy leading to busier seas	Economic activity in the ocean is expanding rapidly, mainly driven by developments in global population, economic growth, trade and rising income levels, climate and environment as well as innovations in offshore energy, aquaculture, and seabed mining.	(The Government Office for Science, 2018) Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand. The Government Office for Science, 2018
Threat of declining coastal economic activities due to sea and land over-use	Climate change, coastal erosion and diverse human activities will compound declining fish stocks, coastal infrastructure, and other economic activities that rely on a healthy and resilient marine environment. Coastal habitats, including estuaries and deltas critical for marine biota and regional economies, have been severely affected by sea-use changes (coastal development, offshore aquaculture, mariculture and bottom trawling) and land-use changes (onshore land clearance and urban sprawl along coastlines, plus pollution of rivers).	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Mining and quarrying, urban mining, seabed mining	Recent political and economic changes have led to increased investment in mineral extraction, directly resulting in land and soil degradation from deforestation, vegetation burning, and mining operations, along with more widely dispersed environmental and social damage. Open-cast and mountain-top mining are particularly destructive, while the collapse of underground mines can also lead to problems such as subsidence, soil erosion, and contamination of water resources. The extraction of high-value minerals generates large quantities of waste, in the	Warnke & Könnölä. 2022. Land use futures, Science, Technology and Innovation for Ecosystem Performance – Accelerating

	order of tens of millions of tons per year, causing siltation of water bodies, acid mine drainage, and leaching of toxic minerals. This waste also creates air pollution, which can affect human health and suppress crop production. Mining – particularly when it is illegal and thus unregulated – also creates high levels of pollution; for instance, the use of cyanide and mercury in gold extraction leads to the pollution of surface and groundwater. Deep sea mining is not yet occurring due the high technology requested and to the issue of managing common good, in the high sea. Since 2001, 31 permits to explore the ocean floor with a view to exploitation have been granted by the International Seabed Authority (the United Nations body responsible for regulating deep-sea mining).	Sustainability Transitions, Foresight on Demand. https://www.iucn.org/sites/default/files/2022-07/iucn-issues-brief_dsm_update_final.pdf https://www.bbc.com/future/article/20230310-what-does-the-high-seas-treaty-mean-for-deep-sea-mining
Tourism	In the context of tourism land use conflicts are rising. For instance, in coastal communities concerns about spatial degradation due to overtourism are increasingly voiced. At the same time demands for recreational and touristic use conflict with other land uses such as windfarms.	Warnke & Könnölä. 2022. Land use futures, Science, Technology and Innovation for Ecosystem Performance – Accelerating Sustainability Transitions, Foresight on Demand.
Transport	Transport arriving by sea, ports; goods moved railways and highways. In addition to land transportation, maritime transportation is an important activity, generating huge impacts, including CO2 emissions. There are currently a lot of efforts done for minimizing its impacts, coordinated by the International Maritime Organisation (IMO).	International Maritime Organisation (IMO)
Land grabbing	Growing global demand for food and the financial investors' interest in the agricultural sector have led to large-scale acquisitions, also known as "land grabbing", of farming land all over the world. The pursuit of agricultural land is not only taking place in developing countries, but also in Europe and the EU, especially in Hungary, Romania and Bulgaria. In Romania, approximately 800 000 hectares farmland, 6% of total arable land, belongs to foreign investors. This process involves the large-scale purchase or leasing of agricultural land by companies, governments and private individuals.	https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/land-grabbing-europefamily-farming
Land abandonment	Land abandonment is regarded as a problem for both societal and ecological reasons. Around 30% (or 56 million ha) of agricultural areas in the EU as a whole are under at least a moderate risk of land abandonment. Land abandonment has specific environmental implications which might threaten the future of semi-natural habitats, the quality of high nature value farmland and linkages of NATURA 2000 sites and highly appreciated cultural landscapes. At the same time, under specific conditions and in certain phases of the abandonment process, beneficial outcomes concerning biodiversity and habitat preservation can be observed.	https://www.europarl.europa.eu/RegData/etudes/ATAG/2021/652241/IPOL_ATA(2021)652241_EN.pdf

Stranded assets	Typically understood to be a productive investment which is no longer economic or legal to use, e.g. as a result of climate mitigation regulation or taxation. Such examples could be coalmines, airports and fossil-fuelled power stations to be stranded. Climate change may leave some assets unused (e.g., in summer 2022 London subway during the heatwave). Also, technology employed in agriculture may end up as stranded assets, for instance when a policy is issued that forbids certain practices because of the negative side effects.	https://doi.org/10.1016/j.oneear.2019.11.012
Declining freshwater sources due to over-use	Competition for already scarce water resources will intensify, leading to difficult and painful allocation choices affecting the public sector, businesses, civil society and ecosystems. Unfortunately, issues of data access and quality prevent leaders at every level of society from comparing priorities for water, evaluating potential solutions and making informed decisions that balance economic, social and environmental interests.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Commons (e.g. fish stocks and deep sea) and associated issues of appropriation and exploitation	The growing trend for exploration, appropriation and exploitation of resources, e.g. the deep sea seabed, which may require new legal instruments. The latest negociations about high sea (the BBNJ Treaty) show that new possibility will emerge for managing biodiversity in the high sea, but this will not include fisheries stocks that are already managed by the current system of RFMO (Regional Fisheries Management Organisations) under FAO. Non-excludable and non-rivalrous goods open to all: national security, air, landscape, public media, many ecosystem services Drivers: environmental degradation, pollution and risks - ecological awareness - urbanisation Impacts: rural places and areas get new attractions and effective brands - diversification of rural economies - increase of environmental conservation and/or reduction of degradation - prospects for non-mainstream farms will improve, e.g. local, ecological, energy	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Digital Economy	Economic activities facilitated by digital technologies and tools; provide productivity gains and platforms for new economic activities. Drivers: technological development - digitalisation -internet – globalization impacts. business benefits (reduced costs, better productivity - new or better rural services and/or better access to services - possibility to adopt new working practices, e,g. remote work, virtual teams - better prospects for both small and large farms.	https://ruraltrends.eu/list-of-all-trend-cards/
Circular Economy	Economic model based on recycling, reuse, sharing and repair of previously extracted materials Drivers: ecological awareness - scarcity of natural resources - opportunities and entrepreneurship Impacts: increase in environmental conservation and/or reduction of degradation - diversification of rural economies - prospicts for non-mainstream farms will improve, eg. local, ecological, energy - newideas and innovations	https://ruraltrends.eu/list-of-all-trend-cards/

3.8 Governance

Title	Description including possible future projections	References

New Governance Models	The challenge of finding an appropriate governance model for contradictory topics related to regions, use of land and natural resources, advocacy etc. Drivers: urbanisation - urban sprawl - protectionist policies and actions - socio-cultural evolution Impacts: better prospects for succession or new entrants to farming - better resourced and targeted local policies - transition toward better problem solving capacity - increase of environmental conservation and/or reduction of degradation	https://ruraltrends.eu/list-of-all-tren d-cards/
Shifting towards multistakeholder governance models	Governments, as the ultimate custodians of water resources, must remain at the centre of the innovation agenda. Allowing government officials to make the most of the Fourth Industrial Revolution will require new solutions that can help them better navigate the complexities of resource-management decisions. How, for example, might technological advancements help local officials better understand and synthesize disparate sources of water-related information in real time? Could the creation of new platforms lower these transaction costs for governments and facilitate more confident and agile decision-making across ministries.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Co-management for sustainable common pool resources	Multi-level governance structure/behavior in the public sector and quasi-governmental institutions, private sector, and the role of NGOs in relation to local-level commons. Among others, tourism is an energy intensive industry with a high carbon footprint, which immensely affects the common pool resources (CPR) and ecosystems. With such combative relation between tourism and CPR, co-management offers a solid platform for institutions and resource users to share power and collaborate to reconcile the strife between tourism and ecosystems.	https://www.sciencedirect.com/science/article/pii/S0964569119303 28X?dgcid=rss_sd_all
Participatory mechanisms	Engagement of citizens in the public decision-making. Citizens assemblies and other forms of deliberative citizen involvement are becoming increasingly popular to develop solutions for contested issues.	Könnölä et al. 2022. Deep Dive 'Climate Change, Research, and Innovation: Radical Options from Social Change to Geoengineering'
Threathened food Security	Availability of food for all at all times is constantly challenged by the weather, diseases, crises, markets, geopolitics, policies and inequality Drivers: coronavirus pandemic, pandemics - new governance modes and models - climate change - crises El Impacts: genesis of novel producer, prosumer and consumer organisations - better or more stable farm income and employment - adoption of new management practices that reduce risks - more demand for local, regional or domestic food	https://ruraltrends.eu/list-of-all-trend-cards/
Food Sovereignty	Antithesis to corporate food regime; emphasis in culturally embedded food systems governed by producers and consumers Drivers: environmentalism - communality, solidarity, equality - bottom-up approach, empowerment # Impacts: diversification of rural economies - better prospects for agro-ecological, environmental or organic farming, farms and farmers - more demand for local, regional or domestic food - new organised opportunities for access to land	https://ruraltrends.eu/list-of-all-trend-cards/
Co-operatives And Partnerships	Agricultural cooperatives have substantial market shares in agri-food supply chains in western countries. Cooperative values such as democratic decision-making, equality and solidarity give cooperatives a unique identity, which differentiates them from other	https://ruraltrends.eu/list-of-all-trend-cards/

	types of enterprise and implies that they have a distinct organizational characteristic Drivers: viability of farm business, productivity - internet - globalisation - problems with access to markets El Impacts: halting of rural decline, preservation of activities - genesis of novel producer, prosumer or consumer organisations - new ways to or more productive interaction positive prospects for specific. types of farms, farm businesses or farming regions	https://onlinelibrary.wiley.com/doi/full/10.1111/joes.12417
Political myopia	Short political cycles, and lack of broad political agreement on alternative paths seem to keep us on the path to the climate crisis.	Könnölä et al. 2022. Deep Dive 'Climate Change, Research, and Innovation: Radical Options from Social Change to Geoengineering'
Emission trading systems	Carbon price, international framework	Könnölä et al. 2022. Deep Dive 'Climate Change, Research, and Innovation: Radical Options from Social Change to Geoengineering'

3.9 Practices and technologies

Title	Description including possible future projections	References
Multiple-use of land	Phenomenon whereby a single plot of land delivers more than one service. Traditionally, most land is dedicated to one function: producing food, producing timber or provision of places to live or work. New land claims (for energy provision, water storage, biodiversity conservation) are hard to fit in, since most land is already occupied. With multi-functional land use, an attempt is made to combine these new land functions with the old ones. For example, not using land fully for food production, but also use it for energy production, water storage or conservation purposes. What makes it difficult is that it requires the traditional land use often needs to become less intensive so as to accommodate the other function. This is only attractive for the landowner when the loss of income is substituted by a payment for the new function.	Warnke & Könnölä. 2022. Land use futures, Science, Technology and Innovation for Ecosystem Performance – Accelerating Sustainability Transitions, Foresight on Demand.
Alternative Food Systems	Diverse community-, delivery, diet- and practice-oriented food systems challenge the dominant food regime. Drivers: environmental awareness - availability and demand for local, healthy, sustainable food products Impacts: expansion of client population (online or new segments) for rural businesses - genesis of novel producer, prosumer or consumer organisations - prospects for non-mainstream farms will improve, e.g. local, ecological, educational, CSA, care, energy. Downsides are that as long as 'mainstream' production lines are still present, for most consumers this presents the most attractive option (cheap and easily available). The question is	https://ruraltrends.eu/list-of-all-trend-cards/

	whether and how alternative food systems can even grow beyond a small niche market.	
Multifunctional Forests	Use of forests for economic, social, environmental and cultural purposes: timber, fuel, food, health, recreation, conservation, carbon sink, hiking, education # Type: trend E Drivers: globalisation - non-rural policies (fiscal, foreign, global, general etc.) - environmental degradation E Impacts: increase in the environmental conservation and/or reduction in the degradation - growth of local rural economies (incomes, jobs) - mitigation of climate change - demand for land will increase for 'other' purposes, e.g. energy, plants, recreation, conservation	https://ruraltrends.eu/list-of-all-trend-cards/
Community-Based Action	Community-based initiatives and actions serve shared interests, capacities, identity, participation and communality in many domains Drivers: bottom-up approach, empowerment ~ community co-operation and development - financial constraints Impacts: more equal and inclusive social fabric - genesis of novel producer: prosumer and consumer organisations new ways to or more productive interaction empowerment ~ prospects for non-mainstream farms will improve, e.g. local, ecological, energy. Downsides are that large-scale structures are often not achievable with bottom-up approaches. Also, the nimby problem is persistent in bottom-up approaches.	https://ruraltrends.eu/list-of-all-trend-cards/
Diversification / Specialisation of Farms	Diversification (on-farm and off-farm) and specialisation are the two main farm business and livelihood strategies Drivers: Common Agricultural Policy (CAP) - empowerment of services - ecological awareness Impacts: diversification of rural economies - better or more stable farm income and employment - prospects for non-mainstream farms will improve, e.g. local, ecological, educational, CSA, care, energy - demand for land will increase for 'other' purposes, e.g. energy. Specialized farms tend to be more competitive than diversified farms. For the latter, a local demand is needed for particular services (e.g. childcare, recreation) which is easily satified by only a few suppliers. Subsidies for agri-environment schemes are another source of income, but the payments are low and the bureaucratic burden is high. Average uptake statistics of agri-environment schemes are fairly low in areas where high production can be achieved.	https://ruraltrends.eu/list-of-all-trend-cards/
Community - owned Rural and Marine Energy Solutions	Energy (biofuels, solar, wind, ocean energy). Community owned wind farms, solar energy systems and bioenergy plants contribute to multidimensional sustainable development Drivers: climate change - ecological awareness - limited energy resources and sources - localism, local paradigm Impacts: growth of local rural economies (incomes, jobs) - diversification of rural economies - more demand for (rural) raw materials (e.g. biomasses) - better prospects for rural energy, service, food, housing etc. communities and cooperatives	https://ruraltrends.eu/list-of-all-trend-cards/
Rural and Marine Business Succession	Large share of farmers and aguaculture entrepreneurswill retire soon that create a major succession problem but it will also also provide opportunities for young people to take over the businesses.	https://ruraltrends.eu/list-of-all-trend-cards/

	Drivers: economic problems, e.g. low incomes, low profitability, price variations - attractiveness of farming, huge investments sunk in the farms (sometimes obsolete due to new environmental legislation), so they become unaffordable for starters. Impacts: better prospects for succession or new entrants to farming - better prospects for both small and large farms, e.g. demand, new outputs, technology - diversification of social capital.	
Smart Solutions in Rural and Marine Space	Maintaining capacity for continuous innovation is essential in rural and marine areas to bring up 'smart' villages, power grids, schools, machines, land and sea use practices etc. Drivers: internet - socio-cultural evolution - digitalisation - globalisation - technological development Impacts: preservation or development of skills and knowledge - access to new business, professional or development networks - better quality of life - better prospects for rural energy, service, food, housing etc. communities and cooperatives	https://ruraltrends.eu/list-of-all-trend-cards/
Technology-Intensive Farming and Aguaculture	Technology provides productivity and environmental benefits but some applications (e.g. genetic modification, lab-grown food) raise ethical, cultural or economic doubts. Drivers: technological development - digitalisation - diversification of farms and farming practices - globalisation Impacts: better or more stable farm income and employment - more demand for local, regional or domestic food - mitigation of climate change - less food waste and more efficient utilisation of raw materials - niche markets will proliferate. Downsides: strong risk on lock-in situations, whereby farmers invest all their capital in technology, and have no financial leeway to respond to new emerging environmental or social problems; the investment often forces farmers to further intensify; the technology is often addressing one problem while it may aggravate other problems; there is a potential mismatch between what a technology promises and what it actually delivers. In the past, technology that increased production per farmer has led to a structural over-supply of food (as farmers tend to hold on to their farm longer than is economically rational). This leads to lower prices and an incentive to produce more and more. This is the typical ratrace of scale enlargement and intensification.	https://ruraltrends.eu/list-of-all-trend-cards/
Rewilding	The practice of "rewilding" has emerged as a method for returning wild lands, and wildness, to landscapes we have altered (Perino et al. 2019). This strategy goes beyond dedicated nature reserves and aims to **restore** self-sustaining and complex ecosystems, with interlinked ecological processes that promote and support one another while minimizing or gradually reducing human interventions. Several national parts are adopting the approach. Rewilding, recognizes and works with complexity and autonomy as ecosystem-inherent characteristics and acknowledges their dynamic, unpredictable nature. Rewilding also emphasizes the emotional experience and perception of wild nature and wild ecosystems without human intervention. Thus, rewilding contributes to increasing requests for spaces where people and especially children can experience and learn about nature. Opponents of rewilding see a risk that particular fragile species will disappear, since the process is fairly uncontrolled. Some species need quite specific management (e.g. mowing). The debate between ecologists about what is better (conserving ecosystems based on some historical benchmark which works well for the preservation of e.g. meadow birds or rewilding, which	Warnke & Könnölä. 2022. Land use futures, Science, Technology and Innovation for Ecosystem Performance – Accelerating Sustainability Transitions, Foresight on Demand. https://rewildingeurope.com/blog/wilder-parks-protected-areas-can-spearhead-

	means letting the natural system take over) is often quite fierce. Fact is that Europe has been cultivated for a very long time, and that most unique ecosystems have come to exist because of some form of management (e.g. Dehesa's, Alpine meadows, heathlands), and that full rewilding will lead to the loss of these ecosystems.	nature-recovery-in-europe/ https://www.iucn.org/sites/default/files/2022-10/principles_of_rewilding_cem_rtg.pdf
Carbon capture and storage and use (CCSU)	Technologies or solvents that extract, capture, transport, and store carbon dioxide released from fossil fuel combustion or industrial processes such as cement manufacture; technically well demonstrated, but not yet successfully commercialised. Growth of organic materia both in marina nd rural areas are important CCSU mechanisms.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Land permaculture	Land-based permaculture, and peasant agriculture - techniques of intensive, high carbon storing land management that run counter to the imaginaries of global agribusiness. While some NGOs and global South activists promote peasant permaculture, there are huge cultural obstacles to it.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Peatland/wetland restoration	Reversing carbon losses from drained wetlands and peatlands by blocking drains and rewetting.	Könnölä et al. 2022. Deep Dive 'Climate Change, Research, and Innovation: Radical Options from Social Change to Geoengineering'
Sustainable food innovations	A sustainable, and transformed, food system, is at the core of a better future. New food initiatives are interesting because they connect the technological, social and environmental domains so profoundly. They include new structures to connect consumers and producers (farmers markets, online platforms), innovative farming systems (urban gardening, permaculture, artificial meat), initiatives to cut food waste (recycled food leftovers from restaurants), and initiatives that underpin protein shifts (new and old forms of proteins, e.g., legumes or insects, that shift us away from meat-based diets).	Könnölä et al. 2022. Deep Dive 'Climate Change, Research, and Innovation: Radical Options from Social Change to Geoengineering'
Increasing use of automation in the marine environment	Autonomation and robotics improving our understanding of the marine environment, facilitating new and more-efficient economic activity, and posing new challenges for communication at sea and the skills base. Autonomy is likely to be the single most important marine technological development. There are a range	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans,

for various activities	of challenges associated with introducing autonomy, including a need for improved battery technology, electric propulsion technology, data transfer and inter-device connectivity.	Seas, Coastal and Inland Waters, Foresight on Demand.
Marine early warning systems become interconnected	Data management of more than 130000 monitoring sites. New or better ecological and chemical monitoring programmes and sites. Scientific monitoring and early warning systems increasingly used also for anticipating societal crisis and emergencies.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Remote sensors and monitoring systems are increasingly deployed	New technologies to measure and monitor the land and ocean including, but not limited to, the use of remote sensing, grab- and nano-satellites, acoustic and electromagnetic sensors, environmental "e-DNA" techniques, autonomous platforms and shared infrastructure.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Resilient agriculture to overcome climatological changes	Resilient agriculture to global change will permit a wider portion of the population to be able to overcome extreme events as droughts and also to be able to cultivate using less water in the long term, but for its achievement a technological advancement is necessary, also in different fields as biotechnologies and a better understanding of traditional agriculture practises. Promising agricultural land uses are worldwide foreseen in revising the complex and efficient rural systems adopted in the past, towards multifunction and resilient agroforestry systems to be adopted in the future. Considering that 70% of water use is for agriculture (AQUASTAT, 2016) and that the growth in population needs to increase agriculture production, optimising water consumption in agriculture will represent a big step towards sustainable use.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Affordable desalination innovations	In the past 30 years alone, drastic improvements have been made in the desalination process, with new technology and enhanced operating systems. According to the Water Desalination Report, current operating plants require only a quarter of the energy compared to systems in the 1980s, due primarily to efficient pumps, membranes and energy- recovering devices. Sun-rich countries, such as Abu Dhabi, are also starting to integrate renewable sources of energy into desalination plants, thereby reducing energy costs and potentially offsetting the energy demand during peak hours. The future of desalination is not only bright in terms of technological advancement reducing cost, but the ability to use natural resources to produce potable water in water-scarce regions is also promising.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Decentralized water collection and treatment systems for households and communities	Development of sustainable and resilient water infrastructure is an urgent challenge for urban areas to secure long-term water availability and mitigate negative impacts of water consumption and urban development. A hybrid system that combines centralized water infrastructure and household decentralized water facilities, including rainwater harvesting and greywater recycling, may be a solution to more sustainable and resilient water management in urban areas. Understanding household and community preferences for decentralized water facilities is	https://www.sciencedirect.com/science/article/pii/S0043135419309080X?dgcid=rss_sd_all

	important to inform the design and ultimately the promotion and adoption of such systems.	
Sustainable aquaculture (e.g. permaculture, seaweed and shellfish)	Marine permaculture is the ocean farming of kelp and seaweeds and can counteract ocean acidification, climate change and loss of biodiversity. Seaweed and kelp can also be a source of biofuel, feed for cattle and could provide food security for millions. Small-scale farms where complementary species are cultivated to provide food and biofuel, clean up the environment, and reverse climate change. Instead of finfish, the anchor crops of green ocean farms are seaweed and shellfish, two organisms that may well be Mother Nature's Rx for global warming. How so? Among other benefits, oysters filter nitrogen out of the water column. Seaweed pulls carbon from the atmosphere and the water, with some varieties capable of absorbing five times more carbon dioxide than land-based plants. Seaweed farms also have the capacity to grow massive amounts of nutrient-rich food and provide a clean replacement for biofuels.	https://www.drawdown.org/solutions/coming-attractions/ocean-farming
Wave and tidal energy	Wave- and tidal-energy systems harness natural oceanic flows—among the most powerful and constant dynamics on earth—to generate electricity. A variety of companies, utilities, universities, and governments are working to realize the promise of consistent and predictable ocean energy, which currently accounts for a fraction of global electricity generation. While the ocean's perpetual power makes wave and tidal energy possible, it also creates obstacles. Operating in harsh and complex marine environments is a challenge—from designing systems to building installations to maintaining them over time. It is more expensive than producing electricity on solid ground. Despite decades of work, marine technologies are still in early development and lag well behind solar and wind. Tidal energy is more established than wave, with more projects in operation today. Across the world, a variety of wave-energy technologies are being tested and honed, in pursuit of the ideal design for converting waves' kinetic energy into electricity. Wave and tidal energy is currently the most expensive of all renewables. Still, the opportunity of marine-based energy is massive. Proponents believe wave power could provide 25 percent of U.S. electricity, for example. Realizing it will require substantial investment and expanded research.	Könnölä et al. 2020. Scoping Paper for the Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters, Foresight on Demand.
Ecovillages	Settlement communities aiming at integration of all four dimensions of sustainable development: economic, social, environmental and cultural Drivers: ecological awareness - slow, peaceful, natural lifestyle - social discontent, lack of social inclusion Ea Impacts: new or better rural development opportunities - migration from urban to rural areas will increase - new organised opportunities for access to land - prospects for non-mainstream farms will improve, e.g. local, ecological, educational, CSA, care, energy Caring the nature	https://ruraltrends.eu/list-of-all-trend-cards/

FORESIGHT ON DEMAND IN SCIENCE, TECHNOLOGY, RESEARCH AND INNOVATION POLICY (ARGE FOD)
Giefinggasse 4, 1210 Wien, Austria

Matthias Weber
Managing Director
+43 50550-4561
matthias.weber@ait.ac.at

Dana Wasserbacher
FOD Office
+43 50550-4520
dana.wasserbacher@ait.ac.at