Federal Ministry
of Education
and Research

Accelerating the green transition

Research for a competitive and resilient Europe within the Earth system boundaries

Priorities for the design of the 10th EU Framework Programme for Research and Innovation

Following the expiry of the current EU Framework Programme for Research and Innovation "Horizon Europe", the 10th Framework Programme (FP10) will form the basis of European research and innovation funding from 2028 onwards. This focus paper provides impetus for the design of FP10 in the thematic area of green transition (sustainability research).

This focus paper complements the German discussion paper for the preparation of the 10th EU Framework Programme for Research and Innovation of the Federal Government, which was published by the Federal Ministry of Education and Research (BMBF) in May 2024 and submitted to the European Commission. It is part of a series of technical papers by the BMBF on the next EU Framework Programme for Research and Innovation.

The focus paper has been prepared under the leadership of the BMBF by the German delegations for the Horizon Europe Programme Committee configurations for Cluster 5 "Climate, Energy, Mobility" and Cluster 6 "Food, Bioeconomy, Natural Resources, Agriculture and Environment" with input from stakeholder consultations. It underlines the **relevance of a strong sustainability research** in FP10 and presents **priority topics and approaches**.

More relevant and urgent than ever: research-based progress for sustainability

Sustainability research is a key driver of the transition to a European model of prosperity that brings together competitiveness, security, cohesion and respect for the Earth system boundaries. Therefore, the 10th EU Research Framework Programme needs to set **sustainability**[i] **as a guiding principle and an overarching focus** for the entire chain from basic research to innovation.

Initial situation

In the face of **geostrategic and economic conflicts** and shifts, Europe's security and competitiveness are under pressure. In addition to armed force and cyber attacks, dependence on resources and products such as food, fossil fuels and rare earths as well as critical technologies are being used as a means of exerting pressure[ii].

Alongside the external tensions, **social disparities** in European societies are increasing, and trust in democratic processes, state institutions and their ability to exercise political control is declining. Concerns about ecological problems are conflicted with reservations about concrete sustainability policy measures and their perceived impact on the economic and social situation.

At the same time, the **ecological crisis** is worsening. The loss of biodiversity and of intact ecosystems as well as soil degradation and the scarcity of water resources are progressing and the negative effects of climate change and pollution are becoming increasingly visible. The countries of the Global South are disproportionately affected by the consequences of the ecological crisis.

The geopolitical, economic, social and ecological challenges are interlinked. Far-reaching transformations with a holistic approach in terms of **sustainable development** for people, planet, prosperity and peace are necessary – as postulated by the United Nations Sustainable Development Goals (UN SDGs). These goals stand for an **innovation dynamic that creates future-oriented prosperity in Europe** and worldwide.

The transition to sustainability is an iterative learning and change process in which society, politics, business

and science work together. Research – especially in European cooperation – plays a crucial role in mastering the demanding challenges, leveraging the diverse opportunities of sustainability, expanding Europe's competitiveness in a future-oriented manner and improving living conditions globally. **Sustainability research is an essential link between science, industry, politics and society**.

Strong sustainability research in FP10

FP10 is intended to initiate transformative changes towards sustainable prosperity within the Earth system boundaries[iii]. This requires

considering **sustainability as a guiding principle and a cross-cutting theme** in all parts of the programme and setting strong funding priorities on specific challenges of the green transition,

- creating new findings, ideas and solutions for sustainability along the entire value chain **from basic research to innovation**[iv],
- maximizing the positive **effects of Research & Innovation (R&I) activities** for progress that ensures good living conditions for future generations through suitable instruments and structures.

Maximizing impact: Designing sustainability research in FP10

In order to create **future-oriented sustainability innovations** and effectively support the complex **transition process towards sustainability**, a coordinated set of impact-oriented instruments is required. Political, strategic as well as inter- and transdisciplinary cooperation between European, national and regional actors and their cooperation with international partners in key thematic areas are important levers for greater impact.

Diverse advances in innovation must be interlinked in order to create sustainable prosperity. FP10 is intended to mobilise and interlink research and innovation in a targeted manner:

- It is the new, **innovative technologies** that often make climate-neutral and resource-conserving economic activity possible in the first place. They are a great opportunity for the future-oriented **competitiveness of the European economy**.
- First-class and up-to-date **Earth system knowledge**, based on sound interdisciplinary Earth observation and including consideration of and attention to the complex relationships between the elements that determine this planet and central planetary ecosystems, the manifold relationships between society and nature, as well as the development of various future scenarios, are necessary as **a central compass**.
- Research on the **societal conditions for success** sheds light on the role of culture, values, norms and behavioral patterns and on the manner in which political, social or economic framework conditions affect social dynamics as well as on how societal support for transition can be strengthened[v].
- In order to advance **system innovations** and transformative change, technological and social innovations must be geared towards the requirements and benefits of various stakeholders in society and tested holistically. The aim is to develop and combine mature and scalable solutions and put them into practice in dialog with users, while taking social, financial and security aspects into account.

Cooperative and networked structure

The **structures and instruments of FP10 are intended to effectively address these R&I objectives** and to be efficiently aligned with them. The funding of collaborative research that is geared towards specific solutions for sustainability challenges plays a key role

in this respect, also as a link between basic research and market-oriented innovation activities. This includes, in particular, relating the various activities to one another and supporting the innovation process towards sustainability as effectively as possible with a holistic perspective (see above-mentioned R&I areas). In this context and with regard to the social aspects of the transition towards sustainability, synergies, among others, with the future cultural and social science programme component of FP10 are relevant. Besides, interfaces to other funding programmes (for example LIFE (L'Instrument Financier pour l'Environnement), ERDF (European Regional Development Fund)) are necessary to advance the **scaling and implementation** of solutions beyond research and development.

In addition to the **coordination at European level, the cooperation between European, national and regional research funding policies** in the field of sustainability is an important lever for greater impact. The aim is to ensure complementarity and efficiency and to create practical **synergies** between funding instruments – beyond previous theoretical options. This requires constructive cooperation, particularly in designing the programme and in the joint implementation.

To promote a knowledge- and evidence-based shaping of the transition, including the further development of the legal framework to support sustainability innovations, an intensive **exchange between politics and research** (science-policy exchange) is necessary. Furthermore, the need for politically relevant assessments (for example IPCC (Intergovernmental Panel on Climate Change) and IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services) reports and reports of the future World Chemicals Council) should be addressed.

Funding instruments and formats

European partnerships, for example in the areas of energy, raw materials, nutrition or biodiversity, are a significant strategic instrument for jointly addressing funding priorities in the field of sustainability at the European, national, regional and international level, and thus achieving greater leverage for their implementation and impact. This instrument – especially the co-financed partnerships – should be simplified in terms of administration, improved technically and deployed strategically for selected sustainability challenges.

Inter- and transdisciplinary cooperation between the natural sciences, engineering sciences and the social sciences, as well as between research, industry, politics, (local) government, civil society and other stakeholders is essential to come up with innovative and practice-oriented solutions. Even the participation of citizens can make an important contribution, for example in projects with a real-world context. The aim is to relate the different knowledge systems with the corresponding knowledge plurality to each other in the best possible way and to use them for sustainability transformations.

Living labs and similar approaches to transdisciplinary research are important formats for developing transition knowledge and for developing, testing and preparing new technologies, concepts and methods for implementation under real-world conditions, preferably with the participation of regional and local interest groups. In FP10, these approaches should be systematically further developed. In particular, greater use should be made of the potential for mutual learning effects and better transferability through projects with similar living labs in different countries. In addition, if necessary, regulatory experimentation clauses should be used to enable the testing of new approaches outside the current legal framework and to help develop the legal framework through regulatory learning.

Research infrastructures are important elements of the R&I ecosystem for sustainability. Transnational access and networking between infrastructures should continue to be specifically supported in terms of efficiency, interoperability and comprehensive use and integration of data.

The networking between projects and the **synthesis** of project results along the various thematic fields should be pursued more systematically, including topic- and stakeholder-specific paths for the economic and societal valorisation of the results. This supports the **transfer** in business, politics and society and makes it easier for subsequent projects to build on findings and experiences.

In order to make greater use of the creativity and originality of young researchers and other stakeholders and to promote potentially disruptive and ground-breaking new ideas, more **flexible funding formats** should be

implemented additionally, which are characterised by a high degree of openness within broadly defined objectives – also with regard to size and structure of the project consortium as well as flexible and adaptive project implementation.

Mission approaches are regarded as a suitable instrument for ensuring progress towards sustainability transformation goals that are associated with high societal relevance and a strong need for research and innovation. The newly introduced **EU missions** in Horizon Europe address relevant sustainability challenges, aim to achieve transformative change, and to this end have defined ambitious, measurable, and time-limited goals. At the end of their term, the successes and limitations of the current missions must be critically reviewed and potential improvements must be identified. It already seems important to focus more strongly and to ensure more consistent responsibility and implementation across programmes, levels and stakeholders, including the inclusion of financial resources for implementation activities, in order to meet the transformative requirements.

International Cooperation

In view of the global nature of the sustainability challenges, R&I cooperation with countries outside the EU must be strategically expanded in FP10. The aim is to

- strengthen scientific and economic **competitiveness and resilience** for mutual benefit;
- jointly develop R&I-based **contributions to global sustainability**.

In doing so, it is important to take into account the changed geopolitical situation and thus support research security[vi], de-risking towards (potentially) problematic countries and the autonomous design of the sustainability transformation. At the same time, it is important to maintain research access to developments critical to sustainability, even beyond partners who share the same values, if this is associated with a clear benefit for overarching goals. Connections and synergies with international initiatives (for example UN Decade of Ocean Science for Sustainable Development, UN Decade on Ecosystem Restoration) should be actively sought.

Important priorities for cooperation with third countries on sustainability issues include the following, among others:

- Climate (system) research and climate services with Africa and India
- Monitoring, reporting and verification of the emissions of all climate-impacting substances, as well as of negative emissions; new forms of climate financing through trading with certificates (especially industrialised and emerging economies)
- Water research and geological research with Africa
- Research on sustainable raw materials exploration and extraction with Africa and South America
- Innovative resource management and circular economy innovations with global technology leaders (for example USA, Singapore)
- Bioeconomy with countries in South America, Southeast Asia, Africa and others
- Research on innovative and sustainable land use with Central Asia, Africa and India
- Sustainable urbanisation in and with African countries
- Use of Artificial Intelligence (AI) to monitor and protect biodiversity, especially in countries that have biodiversity hotspots
- Coastal, marine and cryosphere research
- Energy and hydrogen research

Thematic priorities for sustainability research in FP10

A future-oriented FP10 addresses the research and innovation challenges that are associated with particularly high **leverage for sustainable progress** and significant **European added value**.

The following overarching goals are in focus:

- Regenerative, circular and overall **sustainable economic activity**
- Technological **competitiveness** and **strategic autonomy for Europe**, including reduced dependencies on critical raw materials, fossil fuels and individual supplier countries
- Long-term **future-oriented business models** that take into account the entire value chain
- Increasing and securing the **quality of life** and the level of prosperity while reducing negative externalities
- Protection and **regeneration of ecosystems**, with benefits for people, nature and the economy

Firstly, digitalisation plays an important role as a **cross-cutting issue and principle**. The potential of **digitalisation** and AI for all dimensions of sustainability should be used in a targeted manner, including the utilisation of large amounts of data at the methodological and legal level[vii]. Secondly, a special focus is on leveraging **synergies** between different sustainability goals and at the interfaces (nexus) between different sectors, while addressing issues of resource distribution and competition for land use.

From our point of view, the following thematic areas have high priority:

Sound Earth system governance

High-resolution models, integrated scenarios and digital twins are necessary to create up-to-date and well-founded **knowledge for European agricultural, climate, energy and environmental policy**.

Climate change, loss of biodiversity, soil degradation and pollution have a negative impact on the Earth system. We need to better understand this interplay and its effects on Earth system knowledge – especially with regard to regional and global resilience limits. Opportunities, risks and options for action for various scenarios of Earth system development must be investigated and evaluated. Humans as actors and planetary forces with their socio-economic, political and cultural systems must be taken into account. The knowledge generated should be made available for political and economic decision-making in order to support well-founded considerations that take into account all dimensions of sustainability. Important research goals in this area are as follows:

- Evidence-based approach for European agricultural, climate, energy, biodiversity and environmental policy; strengthening the knowledge base for decision-making (for example cross-sectoral and cross-level monitoring, ex-post and ex-ante assessment of measures)
- High-resolution Earth system models and derived projections for risk prevention and adaptation; understanding of climate processes and observation; foundations for IPCC assessments (support for CMIP (Coupled Model Intercomparison Project = collaborative framework designed to improve knowledge of climate change)); AI in climate modeling; interaction between ocean and climate change
- Digital twins of the Earth and further development of the digital twin concept as an information, planning and decision-making support tool, also for the municipal level
- Further development of integrated assessment models, integrated sustainability scenarios and development of tools to describe sustainability scenarios (for example a concept for a safe and sustainable design for innovations)
- Systematic recording of the effects on and dependencies of biodiversity and ecosystem services with regard to current economic practices and regulations; identification of (indirect) drivers and social causes of the ecological crisis as well as levers for change; foundations for IPBES assessments
- Research on global pollutant cycles, persistent chemical pollution and effective, sustainable chemicals

management; support for the assessments of the future World Chemicals Council

- Research on the framework conditions and further development possibilities of European sustainability policy (including promoting and hindering factors as well as current geopolitical challenges); development and evaluation of governance approaches to accelerate decision-making processes; dealing with conflicting (sustainability) goals across different, interacting regional and sectoral scales and the integration of different social groups

Shaping transition in a pluralistic society in a social and democratic way

We need inter- and transdisciplinary research on the **conditions for shaping the transition** with a special focus on values, participation and the potential of a "Just Transition".

The transition towards sustainability is a project for society as a whole. The social transition is taking place in the context of the European multi-level system. In order to support the transition, the interactions in the overall system as well as the different local challenges and conditions, including the values and norms of different social groups, must be better understood and innovative solutions must be derived from them. An important concept in this respect is "Just Transition", which addresses the social impacts of environmentally related transition policies. Interdisciplinary and transdisciplinary transition research is needed in the following aspects, among others:

- Conditions for shaping the transition in post-factual, polarised times: Preconditions, obstacles, stakeholder constellations, drivers and steering approaches for the transition to sustainable economic and living practices (including the role of the financial sector)

- Socio-economic development paths with an international perspective (development of globally equitable scenarios; international effects of the transition processes in the EU)

- Effects of climate change, destruction of ecosystem services and resource scarcity on conflicts and the stability of political systems

Development and evaluation of measures to strengthen the scope for action of private households for sustainable consumption and lifestyles for specific target groups

- Development and evaluation of concepts for the social organisation of the transition and of environmental policy, including measures to reduce inequalities and strengthen co-benefits for health, for socially just financing of the sustainability transition, for strengthening polluter pays and for the socially acceptable reduction of unsustainable subsidies

- Factors for the diffusion of sustainable (technological) innovations and practices in plural societies; studies on the relationship between needs/individual behaviour and political guidelines, regulations and technical infrastructures

- Educational, communication and attitudinal research as a basis for strengthening the debate on sustainability across social groups

- Systematic evaluation and further development of participatory processes with regard to their sustainability effects and transferability potential. Building on this, participatory development and testing of transition paths with the help of living labs

- Capacity building on sustainable business practices and biodiversity reporting in companies and public organisations (for example integration/linking with reporting on carbon emissions)

Energy technologies and systems of the future

Hydrogen and other storage and energy technologies must be further developed for a **completely climate-neutral and resource-conserving energy supply**, and new long-term options must be developed.

Germany wants to be climate-neutral by 2045, the EU by 2050. The rapid completion of a sustainable, biodiverse- and resource-conserving energy transition is a basic prerequisite for this. Europe's energy security must be strengthened and, among other things, energy imports must be diversified for this purpose.

Climate-neutral and sustainable energy generation and supply as well as improving energy efficiency and the efficiency of the material resources used are crucial. To this end, new energy technologies must be researched and existing sustainable technologies must be further developed, tested and brought to market. European energy research funding should be geared towards the following objectives:

- Further development and integration of renewable energy sources (solar energy, onshore and offshore wind energy, geothermal energy, hydropower and energetic biomass utilisation), including measures to accelerate diffusion and scaling processes
- Resource efficiency and circular economy innovations for the more sustainable production and use of energy technologies (batteries included)
- Innovations to reduce energy demand in industry, urban neighbourhoods, households and the mobility sector, and to promote societal support for new technologies
- Research-based impetus for standardisation of electricity grids and energy infrastructures at EU level and beyond
- (Further) development of smart grids that are able to integrate large quantities of fluctuating renewable energies and simultaneously control the energy flow in real time; resilience of these grid technologies to natural disasters, cyber-attacks and other risks
- Development of efficient storage technologies that enable a continuous and reliable energy supply, especially in the area of batteries and electricity conversion, energy storage, and reconversion pathways from surplus renewable energy (Power-to-X), including hydrogen storage (for example seasonal storage in caverns), as well as the potential of thermal energy storage (for example in underground aquifers)
- Ramp-up of the European hydrogen economy: materials research to create new catalysts and high-temperature electrolysis processes with reduced resource requirements, preparation of international hydrogen value chains, transport of hydrogen (derivatives) over long distances, use of hydrogen

  Assessment of the sustainability of hydrogen and hydrogen derivatives in the context of the overall energy system and in relation to biodiversity and in the environmental mediums of water, air and soil
- Development and evaluation of options for the integration of magnetic/laser fusion in energy systems that are (largely) decarbonised and decentralised
- Research and development into deep geothermal energy as a generation option with a long-term perspective, particularly with a view to expanding potential in the heating sector

Regional and global greenhouse gas management as a contribution to climate protection and nature conservation

Natural and technical approaches to bind CO_2 must be researched and developed.

As greenhouse gas emissions cannot be completely avoided, Carbon Capture Storage (CCS) and Carbon Capture Utilisation (CCU) technologies are needed to capture, utilise or permanently store emissions. In addition, possibilities must be developed to remove greenhouse gases from the atmosphere and thus achieve negative emissions – by means of natural and technical sinks. Measures to strengthen natural sinks (forests, peatlands, other ecosystems) have a special role to play in this regard, as their services have been tried and tested historically and are associated with many co-benefits (water balance, biodiversity, etc.).

- Research into natural and anthropogenic carbon cycles and their interactions as a basis for carbon management
- Research into and development of holistic (ecologically effective, economically efficient, socially equitable) CO_2 management strategies that combine climate and biodiversity protection
- Research and development of practicable and sustainable solutions for CCS, CCU and Carbon Dioxide Removal (CDR), including strengthening and utilisation of natural carbon sinks (for example carbon farming, reforestation strategies, marine carbon reservoirs such as mangroves and seagrass meadows)

Adapting to changing climate conditions and increasing resilience

Innovative, sustainable and customised adaptation measures with a forward-looking impact assessment are necessary to increase resilience to climate change impacts.

Adapting to climate change is a key societal goal. This requires practice-oriented and locally harmonised data and innovations. Measures that are successful in the long term must be sustainable in social, economic and ecological terms. Important areas of research are:

- Adaptation and risk management strategies, including cascading effects and tipping points as well as extreme weather events in relation to various economic sectors, infrastructures and ecosystems (for example agroecosystems, forests, peatlands, coasts, waterways, holistic adaptation in municipalities)[viii]
- Development of suitable, locally adapted adaptation methods including their combination; among others nature-based solutions, technical and societal innovations
- Factors of vulnerability and resilience; possibilities to assess and increase the effectiveness of climate adaptation measures ex-ante
- Effective, motivating and target group-oriented communication and measures to further raise awareness of the effects of climate change and increase social debate on the topic; consideration of innovative concepts such as the Societal Readiness Concept
- International capacity building in the areas of vulnerability, resilience and adaptation, among other things for the protection of natural and cultural heritage from the impacts of climate change

Sustainable urban and regional development and mobility

We need **urban and regional experimental spaces for sustainable and effective innovations**.

Cities, municipalities and regions play a central role in the transition towards sustainability. Citizens have a comparatively high level of trust in this level of the multi-level political system. Municipalities are "implementers" of the transition, where transition knowledge is created and new technologies and concepts are developed, tested and experienced under real conditions. Research and innovation activities must relate to suitable functional areas of interconnection, even if these cross administrative boundaries. Mobility as an indispensable basis for economic, social and cultural activities, but also as a cause of pollutant emissions, noise and land consumption, has a special function. Important fields of research are the following:

- Piloting and testing of holistic and integrative solutions for various sustainability challenges in the city/municipality/region system with evaluation of the territorial, organisational and systemic effects
- (Social) innovations for sustainable and affordable housing and resilient cities (green city, sponge city, blue-green-red infrastructures, regional added value, vibrant city centres, urban production, circular planning and building)
- Innovative (conflict) solutions for multifunctional use of urban areas
- Mobility innovations in urban and rural areas, for example by making individual mobility more environmentally friendly, providing need-based connections and optimising route planning as well as increasing the attractiveness of sustainable mobility options; research into social structures, socio-cultural factors and individual mobility needs as the basis for need-based, affordable, sustainable and resilient mobility
- Intelligent, automated and networked mobility systems for goods and people (including the development of alternative drive concepts) with a focus on public transport, also in conjunction with private-sector mobility offers and services, particularly in areas with

inadequate infrastructure, as well as support for active mobility; systems research to ensure the security and controllability (including cyber security of all components and interfaces) of digital mobility solutions

Circular, bio-based and sustainable economy

To build the regenerative and circular economy of the future, we need innovations such as **bio-based, resource-saving, low-emission and energy-efficient processes, materials and products**.

The establishment of a circular, regenerative and sustainable economy is a key component on the path to climate neutrality, environmental protection, biodiversity conservation and resource protection. It strengthens Europe's strategic autonomy and technological competitiveness. Bioeconomy and circular economy innovations play a central role in this respect:

- Consistent expansion and utilisation of biological knowledge and biological principles for safe and sustainable innovations, among others in biotechnology-based process and product development and in the development of sustainable materials
- Development of processes and infrastructures that bring recovered secondary raw materials with high benefits back into the market (for important components of the energy transition, plastics, composites, electrical appliances, plant fertilisers, among others)
- Substitution of materials that are harmful to the environment or health and materials for which the EU is highly dependent on third parties with bio-based, bio-inspired, regenerative or fully recyclable alternatives, including investigation of interactions and side effects
- Research into the potential of the raw material base of the bio-based economy by collecting comprehensive data on the extraction and use of biomass at EU level
- Bio-bricks, production strains, production platforms and systems as well as further development of the biotechnological toolbox as the technological basis of the industrial bioeconomy

  Discovery, directed modification and valorisation of novel enzymatic activities and material properties (bioprospecting, directed enzyme evolution, among others)
- (Further) development of biotechnological processes and production routes, life cycle analyses to compare the sustainability of different processes
- Piloting and upscaling of innovative bio-based products and services, including the development of recyclable plastics (upcycling); development of bio-based or biodegradable plastics; substitution solutions for critical raw materials in plastics (for example per- and polyfluoroalkyl substances (PFAS) substitutes)
- Research and development to promote circularity for various product classes with the help of a "sustainable by design" approach

Multifunctional land use for food security, biodiversity and climate protection

We need **future technologies and innovative practices for sustainable land use** that overcome conflicts of interest between agriculture and the food industry, climate protection and conservation of biodiversity.

Different land uses compete for land and resources. This conflict is exacerbated by factors such as a growing world population, increasing demand for ecosystem services, changing requirements for animal welfare and environmental protection and climate change. Therefore, holistic approaches and solutions are required, which cover the needs for food production, material utilisation and settlement development while preserving, regenerating and promoting ecosystem services. Research in this sense must take the framework conditions into account and be systemically designed. In the agricultural sector, conventional, ecological and agroecological approaches should be synergistically integrated with a view to the Farm to Fork Strategy. Relevant R&I needs in this thematic area include the following:[ix]

Improving scientific understanding of (nutrient) material cycles, further developing approaches for closed (material) cycles (soil interactions/plant-soil interactions, etc.)

- Research into epigenetic approaches and the increased utilisation of genetic diversity for plant breeding research

- Researching and establishing novel cultivation systems in combination with improved crops and optimised management practices for sustainable yield increases (for example to better harness natural potentials such as the microbiome, biologicals, biocontrols, etc.)

- Development and use of agrobiological systems knowledge for the sustainable management of harmful organisms and invasive species; research into preventive and alternative biocide-free measures; biotechnological processes, phytomedical, phytosanitary and breeding approaches in plant protection

- Further developing key technologies for food systems of the future (digitalisation, miniaturisation, information technology, food biotechnology and agricultural engineering, aquaculture, broad crop rotations and mixed crops, modern breeding research, innovative materials and beneficial organisms, among others) and research them with regard to sustainability and safety

- Potential of high-quality proteins for the health-promoting nutrition of humans and animals

- Research and development of incentive systems for a more plant-based, biodiversity-preserving, resource-conserving and health-promoting diet ("planetary health diet")

- Diversity of land use to protect the climate and biodiversity (carbon farming to increase carbon storage in soils, evaluation and testing of Agri-Photovoltaic (Agri-PV) for simultaneous land use for agricultural production and energy generation); solutions for land use conflicts

Further developing monitoring of biodiversity and effective measures for preventive protection, monitoring, restoration and management of biodiversity and ecosystems (also in combination with multifunctional land use, for example rewetting and agricultural use of peatlands)

- Analysing land use effects along international value chains and developing strategies to reduce negative telecoupling, where sustainable land use in the EU is associated with a deterioration of sustainability outside the EU

Using and protecting water bodies and water sustainably

We need **technological and nature-based innovations for water security** and the sustainable use of oceans, seas and inland waters.

Water is the basis of life for humans and the basis for numerous ecosystems. Oceans cover over two thirds of the earth's surface, making them the largest habitat on earth. Water is essential for the production of food and an indispensable resource for urban development and industry. Climate change, pollution, increasing utilisation pressure and global value chains require increased efforts and innovative solutions for the sustainable management of natural water resources and the safeguarding of the underlying ecosystem services. Important fields of research are as follows:

- New water culture and innovative valorisation of water as a resource, including regeneration and protection of drinking water resources, water security at landscape level

- Understanding, preserving and restoring water-dominated ecosystems in inland, coastal and marine areas

- Long-term effective developments towards a sustainable blue (and bio) economy with environmentally and nature-friendly utilisation of the coasts and seas, including innovations for a more sustainable design of the maritime process and value chain

Innovative approaches and conflict solutions for multifunctional use of coastal, floodplain, peatland and marine areas for food and energy security, biodiversity and climate protection and restoration of disturbed marine ecosystems, including nature-based solutions

- Innovations for the implementation of the EU Net Zero Pollution approach

Innovative technologies for future-proof water management, the use of artificial intelligence, among others; (further) development and evaluation of nature-based solutions for climate protection and climate adaptation (for example sponge cities, green roofs, rewetted moors, floodplains, seagrass); estimation of the retention potential of water catchment areas and evaluation of various forms of water retention

i In this paper, "sustainability" and "sustainable development" follow the understanding of the German Sustainability Strategy. According to this, it is about economically efficient, socially balanced and ecologically compatible development. The planetary boundaries, together with the orientation towards a life in dignity, provide the absolute outer guidelines. In this paper, "sustainable" is generally used in this sense; "sustainable prosperity", for example, implies that the planetary boundaries are observed and social aspects (intergenerational and international justice) are taken into account.

ii While authorities and organisations with security tasks must be able to react to these challenges at short notice, the drivers behind these developments also (continue to) require our attention. See also the focus paper on civil security research.

iii The reference to the Earth system boundaries aims to reduce the negative effects of our lives and economic activity to a level that is compatible with the planetary boundaries – also with regard to international and intergenerational justice.

iv In addition to open, purely knowledge-driven research, this refers in particular to application-oriented basic research that addresses non-scientific needs. It leads to relevant knowledge and inventions in the sense of new, research-based solutions. Innovation is understood as the realisation of such changes (application of new ideas, products or methods). Transfer refers to the transition of scientific findings into innovations. Transition refers to fundamental changes in political, societal, economic or technological development – as the cumulative effect of innovations (and other factors). In line with this paper's focus on research- and innovation-based impulses for sustainable development, certainty of direction and the precautionary principle along the entire chain from basic research to innovation are central guard rails.

v In general, research on social cohesion and for a democratic, culturally diverse and socially just Europe plays an important role in this respect. See the focus paper on European societies of the future.

vi Research security stands for the consideration of overall national security interests and refers to measures that protect research from actors and behaviours that pose an economic, strategic and/or national and international security risk. Risk-orientated measures for research security can improve the basis for scientific freedom, research integrity, open science, transparency and trust-based cooperation for the benefit of both sides.

vii At the same time, it is intended to improve the sustainability of digital technologies (for example in terms of energy, water and resource requirements as well as impact on biodiversity and health). See also the focus paper on key technologies.

viii Civil security research, in which the preparation of the state and society for extreme weather events and disaster resilience are researched, also makes an important contribution in this respect – see the corresponding focus paper.

ix For health-related issues in this thematic area – and others – see also the focus paper on "Health research and innovation for the future of Europe".

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