ANNEX 6 - HORIZON EUROPE CLUSTER 6

FOOD, BIOECONOMY, NATURAL RESOURCES, AGRICULTURE AND ENVIRONMENT

1. Global Challenges and Their Drivers

Human activities – driven by rapidly growing global population, unsustainable economic growth, production practices and consumption patterns – are creating mounting pressures on ecosystems (on land and sea) and on natural resources such as soils, water, air and biodiversity. Since 1970, the global demand for natural resources has more than tripled and is now exceeding "planetary boundaries". Without radical changes in the current, linear modes of production and consumption, the demand for natural resources is projected to double between 2015 and 2050[1,2].

The continuous, accelerating decline in biodiversity is of particular concern as biodiversity provides the fabric of life with a range of ecosystems services which are crucial for human well-being[3]. Main direct drivers of biodiversity loss, in order of their importance, are land use change, overexploitation (through intensive agriculture, forestry and fishing practices), climate change, pollution and invasive species. Underlying causes are production and consumption patterns, human population dynamics, trade, technological innovations, harmful economic incentives and governance[4]. Currently, 27% of assessed species in the EU, in particular pollinators[5], and 66% of habitat types are threatened. Worldwide, about 1 million animal and plant species are now threatened with extinction, more than ever before in human history. The situation may become worse under the business as usual scenario[6]. At the same time, transformative changes could bend the curve of biodiversity loss, but they are currently not happening quick, up-scaled or integrated enough[7].

Natural resources, including biodiversity, are further degraded in terms of quantity and quality as a result of the impacts of climate change. If current trends continue, global average temperature increase could reach 2°C soon after 2060 and continue to rise afterwards, leading

[1] European Commission, Raw Materials Scoreboard 2018
[2] http://www.resourcepanel.org/reports/global-resources-outlook
[3] https://www.ipbes.net/assessment-reports/eca
[4] https://www.ipbes.net/system/tdf/spm_global_unedited_advance.pdf?file=1&type=node&id=35245
[5] EU Pollinators initiative COM/2018/395 final
[6] https://www.ipbes.net/assessment-reports/eca; https://www.ipbes.net/assessment-reports/eca
[7] https://www.ipbes.net/system/tdf/spm_global_unedited_advance.pdf?file=1&type=node&id=35245

to major adverse impacts on primary production systems[8], natural systems and societies in rural, coastal and urban areas[9]. On the other hand, effective management of land and natural resources whilst safeguarding biodiversity can enhance climate change mitigation and adaptation. Agriculture and forestry have a particular role to play in this respect as these sectors manage 80% of the land in the EU[10].

Oceans, seas, lakes and rivers are the lungs and farms of our planet; they produce half of the oxygen we breathe and 16 % of the animal protein we eat. Yet, the health and productivity of our oceans, seas, lakes and rivers is severely endangered by climate change, ocean acidification, deoxygenation, excess nutrients, chemical pollutants and plastics and microplastics.

All in all, the global ecological footprint of human activities has increased from requiring less than one planet Earth in 1961 to more than 1.7 planet Earths today, and is expected to require two planet Earths around 2030[11]. Already now we are reaching or even crossing "planetary boundaries" of Earth system in a number of areas related to nutrient flows (notably nitrogen pollution and depletion of phosphorus) and biosphere integrity[12]. Accordingly, concerns over environment-related risks for the economy are mounting[13].

These concerns are particularly justified for the EU economy, which is largely dependent on fossil resources and many raw materials sourced from international markets[14]. This when, as matter of fact, the mass-scale use of fossil resources has significantly contributed to anthropogenic climate change. Industrial operations represent about 20 % of the EU's total GHG emissions, of which about half originates from the use of fossil resources as raw material and from industrial processes[15]. The use of biomass and waste for the production of renewable products (e.g., chemicals, materials) and nutrients has the potential to strongly contribute to breaking-down the dependence on non-renewable and mineral resources and act as an enabler of the overall bioeconomy.

Environmental degradation in conjunction with unsustainable production and consumption patterns pose also serious risks to human health and well-being. Pollution, responsible for 16% of all deaths worldwide, is the largest environmental cause of diseases and premature

---

[8] Primary production systems include agriculture, forestry, aquaculture and fisheries

[9] https://www.ipcc.ch/sr15/

[10] https://ec.europa.eu/agriculture/sites/agriculture/files/cap-indicators/context/2016/c31_en.pdf

[11] https://www.footprintnetwork.org/our-work/ecological-footprint/

[12]https://www.stockholmresilience.org/research/planetary-boundaries/planetary-boundaries/about-the-research/the-nine-planetary-boundaries.html; https://www.stockholmresilience.org/research/planetary-boundaries/planetary-boundaries/about-the-research/the-nine-planetary-boundaries.html

[13] In the last three years, the environmental-risks have dominated in the Global Risk Perception Survey; and in 2019 accounting for three of the top five risks for the economy by likelihood and four by impact. https://www.weforum.org/reports/the-global-risks-report-2019https://www.weforum.org/reports/the-global-risks-report-2019

[14] https://ec.europa.eu/eurostat/data/database https://ec.europa.eu/eurostat/data/database

[15] Final Report of the High-Level Panel of the European Decarbonisation Pathways Initiative (EC, 2018) https://publications.europa.eu/en/publication-detail/-/publication/226dea40-04d3-11e9-adde-01aa75ed71a1

deaths today[16]. More than 70% of the diseases caused by pollution are non-communicable diseases (NCDs)[17].

Diets inextricably link human health and environmental sustainability. The prevalent unsustainable and unhealthy diets contribute to the global environmental change, and at the same time are the leading risk factor of NCDs and driver of obesity rates. Despite efforts, no EU country has reduced obesity rates in the last several decades[18], and at present more than half of the EU's adult population is overweight or obese[19]. The transformation to healthy and sustainable diets requires substantial dietary shift from the consumers and a change in the food production[20,21]. There is a need to make food systems more responsive to the needs and interests of communities, and to empower people with a stronger influence in local food environments.

Moreover, in an ever-changing environment, keeping plants and animals healthy as well as food supply safe are ongoing challenges. Globally, every year pests and diseases cause around 20-40% of crop and animal production losses[22,23]. Although the food supply in the EU was never so safe as today, the WHO estimates that food-borne bacteria, parasites, toxins and allergens cause about 23 million cases of illnesses and 5 000 deaths in Europe every year[24] and the European citizen is not fully confident or trusting the food supply systems[25,26]. Continuous improvement of risk assessment and risk management methods is necessary to make sure that food stays safe at every stage of the food supply systems.

While addressing all these challenges comes at a price, the costs of inaction and related societal implications would be much higher[27]. If left unaddressed, climate change and the degradation of natural capital risk to undermine public health and many economic sectors, which depend on the health of natural systems and resources. In this context, agriculture,

---

[16] https://www.thelancet.com/commissions/pollution-and-health https://www.thelancet.com/commissions/pollution-and-health

[17] https://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(17)32345-0.pdf; https://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(17)32345-0.pdf

[18] https://www.sciencedirect.com/science/article/pii/S0140673614604608; https://www.sciencedirect.com/science/article/pii/S0140673614604608

[19] http://www.euro.who.int/en/health-topics/noncommunicable-diseases/obesity/data-and-statistics; http://www.euro.who.int/en/health-topics/noncommunicable-diseases/obesity/data-and-statistics

[20] https://euagenda.eu/upload/publications/untitled-74063-ea.pdf

[21] https://www.thelancet.com/commissions/EAT

[22] http://www.fao.org/3/a-i6583e.pdf

[23] http://www.oie.int/fileadmin/Home/eng/Media_Center/docs/pdf/Key_Documents/ANIMAL-HEALTH-EN-FINAL.pdf

[24] WHO (2015) Estimates of the global burden of foodborne diseases, p. 255; https://apps.who.int/iris/bitstream/handle/10665/199350/9789241565165_eng.pdf;jsessionid=8B2AC517A05A7B81BE04E3AF4FC2EAA0?sequence=1255; https://apps.who.int/iris/bitstream/handle/10665/199350/9789241565165_eng.pdf; jsessionid=8B2AC517A05A7B81BE04E3AF4FC2EAA0?sequence=1

[25] https://www.sciencedirect.com/science/article/pii/S0924224418305557; https://www.sciencedirect.com/science/article/pii/S0924224418305557

[26] https://ec.europa.eu/info/consultations/public-consultation-transparency-and-sustainability-eu-risk-assessment-food-chain_en; https://ec.europa.eu/info/consultations/public-consultation-transparency-and-sustainability-eu-risk-assessment-food-chain_en

[27] https://hbr.org/2017/06/if-you-think-fighting-climate-change-will-be-expensive-calculate-the-cost-of-letting-it-happen; https://hbr.org/2017/06/if-you-think-fighting-climate-change-will-be-expensive-calculate-the-cost-of-letting-it-happen

forestry, aquaculture and fisheries, food industry, bio-based and other related sectors will be particularly affected, thereby jeopardizing food and nutrition security, millions of jobs, economic growth, and overall well-being of people, in the EU and globally.

The concepts of the circular economy, the bioeconomy, the blue economy and the Food 2030 initiative provide an opportunity to balance environmental, social, and economic goals and set human activities on a path to sustainability[28]. In addition to new knowledge, technological, innovation, organisational solutions and industrial transformation, implementation of these concepts requires profound changes in people's choices, lifestyles and behaviours as well as appropriate governance models from the local to the global. A transition to sustainable economic growth and competitiveness can only be successful if it goes hand in hand with increased prosperity and is inclusive. This implies a fair distribution of costs, benefits and risks along the value chains and balanced development of rural, costal and urban territories in the Member States, across the EU and globally.

2. EU Policy Objectives

The EU has the ambition to lead the transition to a sustainable, climate-neutral, circular and environment-friendly economy in full compliance with the United Nations 2030 Agenda, the Paris Climate Agreement and the Convention on Biological Diversity, as reiterated in recent communications, notably "Clean Planet for All"[29] and "Towards a Sustainable Europe by 2030"[30].

Many EU policies and strategies have been developed or reformed to foster the transition to an environmentally, economically and socially balanced future. This includes in particular: EU environmental legislation and policies targeting biodiversity, water, soil and air, the Common Agricultural Policy, the Common Fisheries Policy, the Maritime Policy, EU Arctic Policy, the EU General Food Law, the Circular Economy Package, the Circular Plastics Strategy, the EU Bioeconomy Strategy, the Blue Growth Strategy, the Food 2030 initiative, the new Industrial Strategy Policy and the 2030 Climate and Energy Framework.

Research and innovation (R&I) is crucial to better understand the underlying drivers of the sustainability challenges as well as to devise options and a range of solutions to address them. It needs to be matched with investment in technologies, new business and governance models

[28] The transition to a circular economy, including to a circular bioeconomy, is a huge opportunity to create competitive advantages on a sustainable basis. Applying circular economy principles in all sectors and industries will benefit Europe environmentally and socially and in addition have the potential to generate a net economic benefit of EUR 1.8 trillion by 2030(38), result in over 1 million new jobs across the EU by 2030. European Commission COM(2019)22 Reflection Paper "Towards a Sustainable Europe by 2030" https://ec.europa.eu/commission/sites/beta-political/files/rp_sustainable_europe_30-01_en_web.pdf

[29] COM(2018) 773 final, A Clean Planet for all A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy; https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_en.pdf; https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_en.pdf

[30] Reflection Paper "Towards a Sustainable Europe by 2030" https://ec.europa.eu/commission/sites/beta-political/files/rp_sustainable_europe_30-01_en_web.pdf; https://ec.europa.eu/commission/sites/beta-political/files/rp_sustainable_europe_30-01_en_web.pdf

as well as social and environmental innovation to overcome lock-ins and set humanity on more sustainable pathways. Accordingly, R&I can play a key role in achieving objectives set in relevant EU policies and global commitments. These include: meeting the goals of sustainable development, mitigating and adapting to climate change, guaranteeing the production and consumption of safe and healthy food and bio-based products, promoting sustainable practices in agriculture, aquaculture, fisheries and forestry, ensuring access to clean water, soil and air for all, achieving the good environmental status of the seas and oceans, preserving and restoring the planet's vital natural ecosystems and environment.

This is expected to foster an innovative, responsible and competitive European economy generating sustainable jobs and growth.

3. Targeted impacts

R&I in the Cluster 6 aims to advance knowledge, build capacities as well as develop and demonstrate innovative solutions that will accelerate the transition to: a sustainable and circular management and use of natural resources ensuring ecosystem integrity as well as sustainable development and human well-being, including food and nutrition security, in the EU and globally. This will involve user-driven exploitation of environmental big data sources (in particular from Copernicus and Galileo). R&I activities under this Cluster shall create the following interlinked, long-term impacts:

- Reduction of greenhouse gas emissions and successful adaptation of ecosystems and production systems as well as rural, coastal and urban areas to climate change

The climate mitigation and adaptation potential of terrestrial, seas, oceans and inland waters ecosystems as well as primary production, food and bio-based systems will be seized. In particular, GHG neutral and climate-proof production and consumption will be enabled. Negative GHG emissions through sink and storage functions provided by ecosystems and sustainable bio-based resources, materials and products will be actively enhanced. As a result of actions under this Cluster in cooperation with Cluster 4 and 5, European climate targets will be achieved, notably a cut of at least 40% in greenhouse gas emissions (from 1990 levels). In the longer term this will enhance economic, environmental and social resilience.

- Halt of biodiversity decline and restoration of ecosystems

Biodiversity and ecosystem services in natural systems and in primary production will be better understood, monitored, valued and managed. As a result, the decline of biodiversity, including of pollinators, will be reversed and ecosystem integrity and resilience in land and aquatic environments enhanced.

- Sustainable and circular management and use of natural resources; prevention and removal of pollution; healthy soils and clean water and air for all; attractive jobs, enhanced value creation and competitiveness

The physical and biological planetary boundaries in relation to the use and management of biodiversity and natural resources on land and sea will be better understood and defined. This will provide the basis for a more circular use of resources and the mainstreaming of circular systems. As a result, resource efficiency will be increased and pollution will be reduced all

along value chains, from production to consumption and disposal. The resource-efficient management and sustainable use of biological resources will result also in increased added-value along the whole value chains and their competitiveness as well as more attractive jobs in rural, coastal, peri-urban and urban areas. Sustainable management of water resources will help to better cope with the impacts of floods and droughts and reduce the high economic costs related to water pollution control and removal.

- Establishment of primary production, food and bio-based systems based on sustainability, inclusiveness, health and safety; food and nutrition security for all

Sustainable, low emission, resilient, competitive and equitable primary production and food systems will become the norm. The potential of aquatic production systems and aquaculture to produce sustainably high quality food and biomass will be unlocked. Imbalances in our food value chains will be corrected, from agriculture and fishing, to the food and drink industry, transportation, distribution, and consumption. Safe use of bio-resources from land and sea will be ensured. Sustainable, safe and healthy diets will be available and accessible for all and a major shift to healthy diets from sustainable food production systems will be achieved.

- Behavioural, socio-economic and demographic change are well understood and drive sustainability; a balanced development of vibrant rural, coastal, peri-urban and urban areas

Behaviour, motivation, lifestyle and choices of producers and consumers will be better understood. Citizens, as consumers, as producers, as entrepreneurs and as innovators will have equitable access to knowledge and skills required for making informed choices and being actively engaged in sustainable management of natural resources, from production to consumption and disposal. Healthy and responsible production and consumption will become the norm. Mobilising the forces of digital transformation and socio-economic innovation will facilitate those changes and foster a balanced and interlinked development of rural, coastal, peri-urban and urban areas.

- Establishment of governance models enabling sustainability

Policy design, implementation and monitoring will be supported by strong evidence-based knowledge and tools. Innovation systems will be in place and encourage multi-actor, participatory, risk-aware, place-based innovations which in turn will accelerate the development and adoption of sustainable practices. Solid and reliable information from Environmental Observations will allow better understanding of impacts of global changes and enable sound decision making by public authorities. The EU's and international science-policy interfaces will be strengthened to achieve a global impact on the transition to sustainability.

4. Key R&I Orientations

The present section describes the most important short to medium-term impacts that are expected from R&I orientations under each area of intervention. The short and medium-term impacts of R&I orientations will be key for achieving the long-term impacts outlined in the

previous section. As the challenges and impacts under this Cluster are highly interconnected, systems-based approaches will be encouraged. This implies encouragement of multi-actor involvement as well as interdisciplinary or even transdisciplinary approaches in the R&I orientations.

4.1 Environmental Observation

This R&I orientation will support the Commission and the European Union with Environmental Observation-based information and data in the domains of the global science challenges.

The disruptive technologies emerging in the digital economy offer many opportunities in the field of Environmental Observation to deliver information for EU strategy and policies in bio-economy, food, agriculture, natural resources, and the environment.

The main challenge in this area of intervention is to deliver more reliable and standardised information, building on the FAIR (findability, accessibility, interoperability, and reuse) principle, to better understand the impact of global changes and to feed into sound decision making on the big challenges our society faces (links with all the Clusters and AI's in Cluster 6).

The objectives will be reached through facilitating the sharing and integration of environmental data and information collected from the large array of observing systems contributed by countries and organisations within the Group on Earth Observations (GEO). This includes space-based (Copernicus and other space missions), airborne, in-situ and citizens' observations, e.g. through EU platforms such as the European Open Science Cloud (EOSC), the Copernicus DIAS and the European Marine Observation and Data Network (EMODnet) (links with Cluster 4 (Space) and AI4). The approach will also include developing algorithms, using big data and AI (machine learning) to detect and analyse Earth System-relevant information (e.g. in the biosphere), as well as by empowering citizens to contribute to environmental observation and achieve a broader citizens' engagement.

This R&I orientation of work will aim to fill in situ observational gaps and deliver effective solutions for the sustainable use and monitoring of food and natural resources through Environmental Observation, contributing to the Agenda 2030 on sustainable development.

Impacts on the short term consist of better facilitated access to existing ground environmental information through European and global repositories. Furthermore, these efforts will lead to improved time series and geographical coverage of ground environmental observations for e.g. the ocean, Polar regions, and urban and peri-urban areas. It will deliver strengthened partnerships connecting environmental observation with application development groups in the field of food and natural resources, to provide integration knowledge for decision making and resource management. It should lead to upgraded planetary observation systems integrating European systems and benefiting to European users (links with Cluster 4 (Space)). And this should end up in improved European Big Environmental Observation Data Processing/storage facilities connected to the European Open Science Cloud (EOSC).

This area will support Earth system science activities in relevant domains in the context of climate change and biodiversity, such as the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). This includes monitoring to support the implementation of EU nature, climate and agricultural legislation and the EU biodiversity strategy as well as contributions to the delivery of a more sustainable agriculture under the Common Agricultural Policy (CAP) (links with Cluster 5 and AI2, AI3 and AI5).

This area of intervention will support models and data assimilation for the development of indicators, scenarios, service capacity, and innovation. This will be done for many topical fields including biodiversity, species and ecosystem health, climate mitigation and adaptation (including GHG flux monitoring), food security and food safety, agriculture and forestry, land use and land use change, marine and water conservation and use, urban and peri-urban development, renewable energy and natural resources management. It will furthermore support risk assessment and evidence-based policy for ensuring resilient, secure and safe environment-based systems, including farming. It will look into areas of ecosystem resilience, including tipping points, risk prone areas and disaster risk reduction (links with Cluster 3, Cluster 5 and AI2, AI3, AI4 and AI5).

This area of intervention is related to most of the missions and many of the proposed partnerships, in particular, but not exclusively to the partnership 'Agriculture of data' (Environmental Observation for a Sustainable EU Agriculture).

4.2 Biodiversity and Natural Capital

This R&I orientation will support research, innovation and investment activities to guide the development of new methodologies, technologies and solutions, appropriate policy design, and behavioural and economic change to enable the protection, restoration and sustainable management of ecosystems and natural capital.

Biodiversity and natural capital are essential for mitigating and adapting to climate change. To enhance this potential, inter-relations between biodiversity, ecosystem services and climate change mitigation and adaptation, including carbon sequestration dynamics from land and sea, must be better understood (in collaboration with IA4). EU R&I will contribute to accelerate the uptake of ecosystem-based approaches and nature-based solutions to climate mitigation and adaptation, to restore fully functional ecosystems so that they can play their role as carbon sinks contributing to the aims of the Paris Agreement, and explore complementary action in digital, regulatory framework and standards, market, investment, insurance, behavioural and socio-economic areas.

A better understanding of biodiversity and ecosystem services, and impacts of their decline, will mobilise capacities and investments for their conservation, restoration and sustainable management, also through in-situ research across ecosystem types, and thus facilitate the continued provision of all ecosystem services, which underpin our economy and society.

This includes addressing the drivers of biodiversity loss and their interactions – land use change, overexploitation (through intensive agriculture, forestry and fishing practices), climate change, pollution and invasive species, and their underlying causes (production and consumption patterns, human population dynamics, trade, technological innovations, harmful economic incentives and governance) – their temporal, sectoral and spatial effects, the development of solutions to mitigate their impacts and the promotion of practices that enhance biodiversity (together with IA3 and 4). Essential tools that will be developed and improved are projections/forecasts, integrated models, scenarios and pathways that integrate socio-economic value, behavioural and bio-physical factors for biodiversity conservation and restoration, including tipping points and planetary boundaries.

Assessing and valuing biodiversity, ecosystem services and nature-based solutions, and supporting the development and adoption of natural capital accounting frameworks and metrics will support their mainstreaming in public and private decision-making. A necessary pre-condition for efficient biodiversity action is investment into long-term integrated monitoring frameworks and associated tools, including new technologies and approaches (together with IA1), to monitor trends and dynamics of drivers of change and of biodiversity and ecosystem services.

The crash of insect populations calls for a better understanding of its causes and to look for solutions to mitigate its effects on ecosystem functioning and their impact on citizens' life. EU R&I will in particular focus on the role of pollinators in the integrity of ecosystems and the availability of their services, which should help to prioritise and better integrate pollinators into habitat conservation plans and strategies, as called by the EU Pollinators initiative (together with IA3).

Better understanding of the links between pollutants and human health, well-being and ecosystems are needed to develop systemic approaches tackling them (with IA3, IA4, IA5 and Cluster 1). Innovative nature-based solutions will be developed and tested to reduce pollution and revitalise degraded ecosystems and reverse biodiversity decline, notably man-made ones as well as human health. There are still significant gaps in the knowledge of environmental behaviour and eco-toxicological features of chemical compounds and mixtures. Their characterisation could be related to questions on human toxicology and exposure (Cluster 1).

Assessing how extraction, production, consumption, trade, and behaviour patterns, especially primary production and food systems, affect biodiversity loss and ecosystem services, and how ecological transitions can be socially fair is a priority. Better understanding on how measuring and valuing natural capital changes the public and private decision making at all levels is needed, including for business and investors, and for exploring solutions to improve the biodiversity impact of retailers in global value chains. Impacts of digital transformation, new emerging technologies and social innovation on biodiversity need to be addressed. This includes maintaining materials in the economy for as long as possible and comprehensive assessment methodologies for nature-based solutions in business and for social justice (performance indicators, standards, reference models, risk analysis, life cycle assessment). A

robust science and evidence base will in turn contribute to EU coordinated action on the sustainable finance action plan, so as to shift investment towards more biodiversity-friendly activities.

Development of innovative governance models, participatory approaches and integrated decision-support tools are expected to enable systemic approaches and a swift implementation of policy actions for meeting sustainability, biodiversity and climate challenges set towards 2030. Successful transition to sustainability requires an agreement in the communities on the preferred options for development beyond the identification of feasible options to address an acute problem. Multi-stakeholder living labs that allow co-creation of systemic solutions and create space for testing them are innovative governance solutions that implement the 'innovation principle' not restricted to biodiversity and natural capital in the strict sense but address transition processes more broadly. Related activities aim at understanding behavioural, socio-economic and demographic change as drivers of sustainability and catalysts for a balanced development of vibrant rural, coastal, peri-urban and urban areas. Science-based tracking mechanisms and methods would enable transparent assessment of their effectiveness. Activities will engage communities of innovators, public authorities, business and public in all parts of the science-policy cycle, including through citizen science, for facilitating co-creation of actions on natural capital and biodiversity.

Another targeted impact is the improved science and knowledge base, science-policy mechanisms and tools to support the workings and outcomes of IPBES and IPCC and multilateral environmental agreements (see international cooperation).

4.3 Agriculture, forestry and rural areas

Sustainable, climate-friendly and resilient farming and forestry systems provide a number of economic, environmental and social benefits. In addition to contributing to food and nutrition security, feeding into dynamic value chains, providing millions of jobs and securing well-being of people, EU's farmers and foresters are important stewards of the natural environment, and thus have significant potential to shape and maintain rural landscapes, promote healthy ecosystems, mitigate the effects of climate change and halt the loss of biodiversity. EU research and innovation activities under this intervention area are expected to advance knowledge, build capacities and develop solutions to use land in more sustainable ways and to move to climate-friendly and resilient agriculture and forestry systems. This transition will be supported by applying principles of agro- and forest ecology and making better use of ecosystem services. R&I will also contribute to providing consumers with healthy and nutritious food, developing new value chains and to a balanced development of rural areas, based on implementation of effective, evidence-based policies.

Fostering climate change mitigation, and achieving sustainable management and efficient use of natural resources implies for agriculture and forestry that there is a right balance between

productivity, climate and environmental goals. R&I will unlock the full potential of LULUCF[31] activities in the mitigation of climate change. New technologies and business models will further enable a "de-fossilisation" of land-based primary production (in cooperation with Cluster 4 and 5, and IA2). Results of funded activities will benefit forest management and the delivery of multiple services provided by forests, such as the provision of goods, the protection of soils, water and biodiversity or their contribution to climate change adaptation and mitigation.

A range of approaches will be developed to enhance resource use efficiency in agriculture and forestry, find alternatives to scarce resources such as water and decrease the dependency on critical raw materials (together with IA5 and Clusters 4 and 5). A better understanding of the nutrient flows and the role of biodiversity as well as a more effective integration of legume crops in farming systems will allow to optimise nutrient management and reduce pesticide use on-farms and across landscapes, thereby also decreasing pollution of water, soil and air from primary production. By better linking rural, peri-urban and urban resource flows it will be possible to gain value from residues and by-products, unlock the potential of the circular economy, and hence create attractive jobs in rural communities, in particular by promoting small-scale, bio-based solutions (in cooperation with IA6) and innovations in farming at the interface between agriculture, aquaculture and forestry.

Agriculture and forestry are severely affected by more variable and extreme weather events and there is an urgent need to foster adaptation of primary production to climate change. R&I outputs are expected to increase the resilience of plants and animals to biotic and abiotic stresses by bringing more diversity into farming and forestry systems and provide farmers with better-adapted crop varieties and animal breeds. Moreover, R&I outputs will provide solutions for rural communities to mitigate and adapt to changing climatic conditions, in particular by introducing innovations in the areas of renewable energy, mobility and natural disaster prevention (together with Cluster 3 and 5).

Biodiversity and ecosystem services underpin productivity and resilience of agriculture and forestry; their preservation and restoration at farm, forest and landscape level is therefore essential. Increased knowledge on the benefits of biodiversity-rich and pollinator friendly practices will serve to develop farming and forestry systems that protect, restore and enhance agrobiodiversity, wild biodiversity and ecosystem services across a range of scales. The planned partnership "Accelerating farming systems transition: agro-ecology living labs and research infrastructures" will support implementation and upscaling of agro-ecological approaches in primary production, including organic and mixed farming or agroforestry. R&I outputs will improve conservation, management and use of plant and animal genetic resources, thereby preserving and enhancing agrobiodiversity. Furthermore, results delivered

[31] Land Use, Land-Use Change and Forestry (LULUCF), for more information see: https://ec.europa.eu/clima/policies/forests/lulucf_en:

by R&I will allow to better assess the impacts of primary production on biodiversity, identify the ecological boundaries of the bioeconomy and deploy nature-based solutions to enhance biodiversity (in cooperation with IA2).

Health and safety in agriculture and forestry, and of their produce, as well as animal welfare are important societal concerns. Addressing these concerns will require a multidisciplinary and systemic approach. Results of R&I under this orientation are expected to enhance capacities to prevent, monitor and control animal and plant pests and diseases including emerging risks. This will result in the development of safe and environmentally friendly methods for plant protection and weed control that substantially reduce the use of contentious pesticides, and thus also enhance the health and well-being of workers in agriculture and forestry, of consumers and of ecosystems (in cooperation with Cluster 1). With regard to improving animal health and welfare, activities will result in a better understanding environmental and socio-economic drivers of diseases and promote innovative integrated approaches to animal production. The planned partnership "Animal health: fighting infectious diseases" will tackle transboundary animal diseases, anti-microbial resistance and will allow to advance in the implementation of the One-Health concept (in cooperation in Cluster 1).

Knowledge on structure and functioning of food and non-food value chains will support the creation of new value chains, in particular for a wide range of eco-innovative products of high quality based on plant proteins, fruit and vegetables that meet growing consumer demand for healthier and more sustainable diets (in cooperation with IA5 and Cluster 1). R&I results will contribute, in particular, to the development and strengthening of the EU-grown plant protein[32] and organic sectors[33]. They will improve the organisation of value chains and stimulate collaboration among farmers, producer organisations and other actors. This will ultimately lead to greater diversity, transparency, efficiency and competitiveness, more added value and balanced power relations across the whole food and non-food value chains (in cooperation with IA5).

The socio-economic and demographic changes in rural areas jeopardise the cohesion of the EU territory. Results of R&I will feed into strategies and policies to close the divide between rural and urban areas and benefit vulnerable groups, rural dwellers (in line with Cork 2.0 Declaration) and generational renewal in farming and rural communities (in cooperation with Cluster 2). The development of digital services and skills as part of the digital transformation will enhance connectivity of often remote rural areas (including mountain areas) and support smart rural communities and businesses (in cooperation with Smart Villages and POSEI, and Cluster 4). This will result in a better understanding of social networks, social capital and social innovation processes and allow for innovations in rural communities which valorise

[32] Report from the Commission to the Council and the European Parliament on the development of plant proteins in the European Union (COM(2018) 757 final).
[33] https://ec.europa.eu/info/food-farming-fisheries/farming/organic-farming/future-organics

local and regional assets as well as improve well-being of people living in rural areas (in synergy with the LEADER programme).

To develop governance models for sustainability, R&I is expected to deliver the necessary data and knowledge base for improving monitoring and evaluation of EU policies addressing agriculture, forestry and rural areas in the period 2021-2027 and beyond. They are expected to deliver foresights and tools for multidisciplinary assessment of sustainability and circularity, lock-ins and transition pathways. Moreover, observation networks of European forests are expected to be created and data related to forests harmonized.

Agricultural knowledge and innovation systems (AKIS) as well as social innovation will be key drivers to speed up the take-up of results. This will include promoting place-based innovations, reinforcing the multi-actor approach and establishing a network of living-labs in agro-ecology.

Due attention will be given to ICT as an enabler, allowing to build an open digital environment and supporting bottom-up innovation in agriculture, forestry, related value chains and rural areas (together with IA1 and Cluster 4). This is in line with the recent declaration of EU Member States on "Smart and sustainable digital future for European agriculture and rural areas"[34].

4.4 Seas, Oceans and Inland Waters

Seas, oceans and inland waters have a central role in climate processes and in the provision of food, biodiversity, critical ecosystem services, renewable energy and other resources. Oceans, seas and inland waters can deliver more food with lower carbon and freshwater footprints than land-based production, while boosting profitability in the sector. Crucially, the ocean economy needs to prepare for and adapt to alterations in the marine ecosystem – notably from climate change and ocean acidification – requiring integrated management frameworks leading towards win-win outcomes for the ocean economy and the ocean environment from Antarctica to the Arctic. Furthermore, the health of the ocean, its conservation and protection are a prerequisite to benefit from the ecosystem services.

Contributing to the above, science, technology and innovation are key to the development of a sustainable ocean economy, along with skills and education, ensuring that by 2030 the potential of oceans, seas and inland waters, their ecosystems and bioeconomies to drive a healthy planet is fully understood, unlocked and harnessed.

Designing and deploying an integrated approach (looking at the interlinkages of ocean-climate, ocean-food, ocean-land, ocean-society, renewable energy from marine sources, marine biodiversity, etc.) will lead to systemic solutions that by design respect the health of

[34] https://ec.europa.eu/digital-single-market/en/news/eu-member-states-join-forces-digitalisation-european-agriculture-and-rural-areas

seas and oceans and planetary boundaries. Knowledge and innovative solutions will support evidence-based policy making and implementation through engagement and dissemination actions and assessment at EU and global level[35].

Climate change mitigation and adaptation will be enhanced through the improved scientific knowledge and innovations that will allow to better understand, forecast, monitor the ocean and its changes (including sea level), the climate-ocean interface and the impact of stressors and global changes on ecosystems and maritime sectors[36] as well as on inland waters and related economic activities and human settlements. The development and demonstration of Greenhouse gas "neutral" and climate-proof production and exploitation innovations will contribute to climate neutrality and support the adaptation of fisheries, aquaculture and sustainable exploitation of ecosystem services and other resources in the context of climate change and other global changes (in cooperation with Clusters 3, 4 and 5).

Preservation and restoration of biodiversity and ecosystem services will benefit from increased understanding of marine biodiversity and other biological resources, marine ecosystems, planetary boundaries and ecosystem services at sea and in coastal areas[37] (together with IA2), including fisheries for the sustainable use and management of natural resources at sea, environmental protection, coastal management, food security and food sovereignty. The development and demonstration of the use of ecosystem-based approaches and other systemic solutions will allow to protect and sustainably use and manage marine biological resources and to enhance ecosystem integrity and resilience in marine and coastal environments.

Sustainable management of inland water, coastal and marine resources will be achieved through innovative solutions (including circular economy business models and social innovations – together with IA7) to reduce stressors and human induced pressures on freshwater and marine ecosystems and human, algal and animal health, facilitating the development and market uptake of sustainable circular bio-based processes and blue bioeconomy products.

Contributing to global food and nutrition security, will be realised through developed and demonstrated solutions to produce more, safe, healthier and better quality food, and by exploiting new food sources from the seas, oceans and inland waters, whilst conserving biodiversity, thus alleviating pressure on land and fresh water resources and boosting profitability in the sector. This will go hand in hand with sustainable and resilient aquatic

[35] EU policies such as the Common Fisheries Policy, the revised EU Bioeconomy Strategy, the Integrated Maritime Policy (including the Marine Strategy Framework Directive), Martime Spatial Planning and International Ocean Governance as well as the 2050 Clean Planet vision.

[36] Investigate the impacts of climate change on marine and coastal ecosystems, examining effects in terms of ocean acidification, sea level rise, temperature and currents changes, extreme events, deoxygenation, eutrophication, abundance of marine resources and food, and other effects on marine sectors;

[37] This includes research needs from the ongoing negotiations on Biodiversity in Areas Beyond National Jurisdiction (BBNJ)

food production systems that minimise the use of chemical inputs, nutrients and antimicrobials, and guarantee the transparency and traceability of aquatic food products (together with IA5).

Establishment of governance models enabling sustainability will benefit from the results of R&I, improving capacities and skills to reap the benefits of digital transformation and socio-economic innovations for more resilient, prosperous, sustainable and dynamic inland water, coastal and maritime economies, also by developing management frameworks aligned to policy objectives and ensuring fit for purpose ocean observations[38] (together with IA1), interconnected with relevant research infrastructures[39], to serve the needs of decision and policy making.

Prevention of pollution (chemical, physical, bacteriological, nutrients) and required behavioural and socio-economic changes will be addressed through R&I leading to solutions to limit pollution in inland, coastal and marine waters from maritime infrastructures and transport, energy infrastructures and tourism and by demonstrating adoption of circular economy products to prevent and mitigate littering and polluting. Special attention will be given to the river catchment areas and the quality of the cleaned waste water entering coastal waters.

Cost-effective solutions for mitigation of morphological alterations of water bodies (e.g. barriers, dams, canalisation) and for restoration and management of heavily modified water bodies will help to preserve and restore biodiversity and ecosystems. Innovative solutions, improved analytical tools and monitoring methods to address the negative effects of past chemical stressors and new emerging pollutants (such as micro-pollutants, micro-plastics, pharmaceuticals) will also help improve the chemical status of freshwater and prevent further pollution, both in inland water bodies and coastal waters (in cooperation with IA7).

A planned overarching partnership "A climate neutral, sustainable and productive Blue Economy" will cut across several of the above impact areas and it will have a key role in achieving the desired impact on a sustainable Blue Economy, creative value added, blue growth and jobs in Europe through a jointly supported R&I programme in the European seas, coastal and inland waters.

Multi-lateral cooperation with international partners will be pursued to achieve the goals mentioned above, notably in the Atlantic, the Mediterranean,the Black Sea and the Arctics.

[38] Technologies for the digital ocean (seafloor, water column and water surface) connecting services and communities, and promoted through the Blue Cloud as part of the European Open Science Cloud.

[39] Such as those identified by the European Strategy Forum for Research Infrastructures (ESFRI) and those established under the European Research Infrastructures Consortium (ERIC) regulation

4.5 Food Systems

The global food system is facing a range of challenges including the triple burden of malnutrition (undernutrition, over-nutrition and micronutrient deficiencies), climate change, resource scarcity, biodiversity loss, including in soils, growing and ageing population, urbanization, food waste and food poverty. This requires food systems' transformation with a shift towards more sustainable and healthy diets aiming to ensure food and nutrition security for all. Food sector is also an important part of the European bioeconomy market in terms of turnover and employment at 50% and 19% respectively[40]. The Food 2030 initiative will support the transition with a systemic approach to make our food system future-proof.

A better understanding of the interactions between the different components of the current food systems will accelerate the transition towards a sustainable, climate-neutral, resource-efficient, trusted and inclusive global food system from land and sea that respects planetary boundaries and delivers safe, healthy and affordable food to all. Innovative solutions and strategies that tackle systemic issues and have high social, environmental and economic impact will play an essential role. R&I will contribute to promoting sustainable and healthy diets; preventing the risks of non-communicable diseases; building the food safety systems of the future; ensuring a more diverse and sustainable protein availability; reducing food waste and rethinking packaging; valorizing the potential of new microbiome knowledge; realizing urban food systems transformation; and building on digital innovations in a coherent food system approach.

To foster climate change mitigation and adaptation, R&I solutions will be developed to improve resource efficiency and circularity, to reduce food waste, rethink packaging and address environmental pressures impacting on the food systems. Results of R&I will provide a diverse range of more sustainable and nutritious foods, such as plant based proteins, algae, seafood and insects based proteins, and improve the climate-resilience of food systems. Placed based food innovation will be supported and R&I solutions applied also in urban and rural contexts to ensure the transformation of urban and peri-urban food systems.

The food systems is an important part of the bio-economy, it draws on the services of the same ecosystems whose limits have to be respected. For the preservation of biodiversity and ecosystem services and resources food systems have to create synergies with the bioeconomy, notably for the better use of byproducts and wastes. Sustainability, inclusiveness, safety and health will be embedded in food systems and food and nutrition security ensured. Innovative personalized nutrition solutions will provide a better understanding of needs and predispositions to develop tailored solutions for different targeted groups and in particular for people in vulnerable stage of life to reduce the incidence of diet related and non-communicable diseases (in cooperation with Cluster 1). The potential of the

microbiome will open new avenues to improve human health, biodiversity of food resources, sustainability and climate resilience across food systems (in cooperation with Cluster 1 and IA3). Addressing health and nutritional inequalities is crucial to reduce hunger and malnutrition and to support the sustainability transition. Innovative solutions and strategies tackling the causes of food and nutrition insecurity and identifying emergency responses at different levels (cities, regions, etc.) and for different communities (developing countries, vulnerable groups like elderly, migrants, low income groups), will ensure that nutritious, sustainable and safe food is available, accessible, and affordable for all, and at any time (in cooperation with Cluster 1, Cluster 2 and IA3). Challenges to and innovation in the food chain will be addressed by improved risk assessment methodologies and new evidence to support robust food safety regulatory frameworks, including new and emerging food safety risks. R&I will foster solutions for acceptability, trust, transparency, and innovation uptake by citizens. The development of digital innovation will optimize the sustainable use of natural resources along the food system and contribute to foster food safety, crisis management, traceability, transparency and system resilience, to respond to the trend for more personalized, sustainable and healthy food, and to increase EU food industries competitiveness. R&I solutions for food products, services and process will optimize nutritional, structural and functional food properties, food systems sustainability and resources efficiency, reduction and recycling of water, food loss and waste, and the reduction of plastic based food packaging.

Behavioral, socio-economic and demographic changes will be well understood and drive policies. R&I solutions to better understand the factors (such as urban planning, obesogenic environment, cultural and socio economic factors) influencing consumer food choice, their lifestyle and their motivation with a special attention to vulnerable people will facilitate transition towards sustainable and healthy production and consumption. Safe and healthy diets will not only reduce the risk factors of diet-related and non-communicable diseases, but is essential for reaching climate targets[41] and supports more environmental friendly production systems. European food industries should be involved as they have an essential role to play in facilitating dietary change by providing good quality, safe, affordable and convenient food with good nutritional (e.g. functional food adapted to different target groups) and sensorial qualities.

Citizen's empowerment and involvement in informal governance systems will be crucial to shift consumer preferences and consumption pattern towards more sustainable and healthy diets. Interfaces between informal and formal governance systems need to be developed and tested to accelerate innovations uptake in society. To develop and establish governance models enabling sustainability, R&I will produce knowledge and innovative solutions to

[41] COM(2018) 773 final, A Clean Planet for all and SWD: Dietary changes can by 2050 reduce EU GHG emissions equal to 5% of 1990 levels

support evidence-based policy-making, implementation and monitoring and to strengthen EU and international science-policy interfaces for improved governance. By addressing political and socio-economic lock-ins starting from the local level of governance, these solutions will ensure policy coherence and societal engagement in developing and applying science-based innovative solutions.

The contribution of the proposed partnership on "Safe and sustainable food systems for people, planet and climate" will cut across several of the above impact areas and will have a key role to support food systems transformation including post-harvest food production and sustainable and healthy diets.

4.6 Bio-based Innovation Systems

Bio-based innovation has a major role to play in the transition to an economy which is climate neutral, circular and operates within planetary boundaries. Building on the use of biological renewable resources, as a substitute for fossil- and mineral-based ones, it fosters climate neutrality in very significant parts of European industrial and economic sectors (e.g. construction, packaging, textiles, chemicals, cosmetics, pharma ingredients and consumer goods). It contributes to achieving the goals of the Circular Economy – for instance through the development of our capacity to turn organic waste into valuable products. At the same time, it capitalises on the enormous advances of biosciences and biotechnology to deliver greener and innovative products, processes and services. The transformative potential of bio-based innovation will also be directed towards economic competitiveness (in cooperation with Cluster 4 for industrial symbiosis), delivering new value chains, technologies and processes, economic activities and employment, thus revitalising regional economies and local areas.

The contribution of bio-based innovation to fostering climate change mitigation and adaptation strongly relies on the provision of sustainable biomass, grown in a way which respects climate and biodiversity goals and sustains ecosystems integrity, and its conversion into bio-based products and nutrients as a substitute of fossil and mineral-based ones.

R&I is expected to deliver on two main outcomes. First and foremost, it will result in resilience and sustainable biomass production systems for high value bio-based products while ensuring the functions of balanced ecosystems (terrestrial, aquatic) with greater carbon sequestration and biodiversity conservation. A number of ecological approaches can be considered such as multi-cropping strategies, 'agro-forestry', multipurpose biomass, the use of perennials and marginal lands, residues mobilisation and use as well as climate-resilient crops (e.g. drought, pathogen resistant) (in cooperation with IA3). Secondly, it will pursue the establishment of new bio-based value chains through the development of a toolbox of solutions to process diverse biomass into bio-based products, including in advanced sustainable biorefineries, including small-scale decentralised models (in cooperation with IA3). A key approach will be the combination of sustainability and functionality of the developed products. Bio-based products may be suitable for various (longer-term) uses, and

new end-of-life requirements (such as recyclability, compostability), should show lower toxicity on the environment (e.g. bio-based surfactants, pesticides, insecticides) or present new functionalities (e.g. drugs based on chemical composition or structure) or performances (biodegradability in specific environments) meeting societal needs.

Coupled with its potential to reduce greenhouse gas emissions, bio-based innovation can accelerate the transition from a linear fossil-based economy, which leads to overuse and depletion of natural resources, into a resource efficient and circular bio-based one operating under safe planetary boundaries. R&I is expected to result in solutions to keeping the value of biological resources in the economy for longer through the optimisation of product design, production processes, performance and end-of life, including reuse and recycling patterns. Effective approaches will be devised to the increase of the value generated per unit of biological resources. They could range from the optimisation of the chemical (complex molecules), materials and energy potential of the feedstock to the implementation of the principle of cascading use of biomass. Greater value will also be generated from unavoidable biological wastes and residues, including urban bio-waste and residues from agriculture, food processing, forest sector, fisheries and aquaculture. Also the recovery of nutrients from waste streams to produce bio-based fertilisers will allow for reducing impacts associated to the production and use of synthetic fertilisers. As bio-based products and processing may decrease the presence of hazardous substances, they could improve safety and facilitate circularity. Industrial symbiosis will enable the creation of new value chains and networks where wastes or by-products of an industry or industrial process become the raw materials for another. This includes the capture and use of CO_2 from emissions from bio-based processing into valuable chemicals, materials and products. The flows of biological resources will be better integrated into models of the circular economy, in particular on the circular use of natural resources that account for its ecological boundaries and enhance biodiversity and the delivery of ecosystem services, and metrics and data on the value generated per unit of biological resources will be developed.

With a view to addressing the previous R&I priorities (in cooperation with IAs 3, 4, 5 and 7), the suitability of the establishment of a potential European partnership in the area of "Sustainable, inclusive and circular bio-based solutions" will be assessed against the compliance of a possible proposal with Horizon Europe selection criteria and targeted impact.

Bio-based innovation is not only driven by the need to address pressing societal challenges (such as climate change, resource depletion, biodiversity loss, environmental pollution) but also by the disruptive potential of the unprecedented advances in life sciences and biotechnology. This goes far beyond biomass processing towards allowing the use of nature's "biological assets", i.e. its functions and principles. R&I is expected to deliver competitive, sustainable and novel industrial processes, environmental services (e.g. bioremediation for restoring ecosystems, water resources, soil) and consumer products through the application of biotechnologies across bio-based value chains (e.g. chemistry, construction). When coupled with the digital revolution, new tools will be put in place for prospecting, understanding and sustainably using the biological resources (in cooperation with IA 2).

Maximising the impact of bio-based innovation involves the elaboration and establishment of governance models enabling sustainable and inclusive bioeconomy patterns. This key targeted impact cuts across all key R&I priorities identified above. R&I is expected to deliver behavioural and socio-economic change resulting in (i) the revitalisation of local communities through e.g. new (small-scale) business models and innovative contractual arrangements in value chains, (ii) effective public engagement, mobilisation and mutual learning, trust building and awareness raising, (iii) training and skills development as well as recruitment strategies and education. R&I is expected to result in a deep understanding of multiple boundaries of the bioeconomy. This includes knowledge for evidence-based policy making on (i) bioeconomy impacts, synergies and trade-offs with a healthy environment, enabling their comparison with concurrent and alternative economies (fossil-, CO_2-based), (ii) (international) biomass sustainability criteria and certification schemes, (iii) hierarchy of use of biological and fossil resources (e.g. trade-offs and synergies with food production or other land use). Technological, as well as systemic, territorial, social and environmental innovation will be supported.

4.7 Circular Systems

The recent EC report on the implementation of the Circular Economy Action Plan, the EU Plastics Strategy, the updated EU Bioeconomy Strategy, the reflection paper towards a Sustainable Europe by 2030 and the Clean planet for all strategy acknowledged the need for further progress in scaling up circular economy, reducing pressure on the environment and consolidating the competitive advantage it brings to EU businesses. There is need to: (i) continue supporting research, innovation and investments to develop and demonstrate innovative systemic solutions in various sectors (e.g. plastics, food, textiles, electronics, construction and built environment) and reap their full benefits to cut greenhouse emissions; (ii) address the challenges related to the circular use of natural resources, including recycling, energy and material efficiency; (iii) support new circular business models, and consumption and production patterns; (iv) enhance circularity and sustainable water use and circular nutrient and manure management; (v) develop appropriate indicators and governance systems to measure the progress and accelerate the transition to the circular economy.

Improved knowledge about the potential and the overall environmental impact of circular economy will contribute to reducing GHG emissions along value chains and to fostering mitigation and adaptation to climate change. Investing in systemic solutions for circular economy at regional and local scale (in urban, peri-urban, coastal and rural regions) including new business models, products and services stimulating resource efficiency along the whole value chain, while exploring the potential of digitalisation, will contribute to reducing the environmental footprint of production and consumption, preventing pollution and achieving sustainable management and circular use of natural resources. The development of a holistic view of a working after-use system in particular for plastic based products, incorporating reuse, collection, sorting, mechanical, chemical and organic recycling will also provide insights on how to coordinate strategically the transition towards a circular economy for plastics and other key material flows and support the implementation of relevant EU policies.

Robust approaches to promote active engagement of citizens, to explore the consumer-related aspects of circular economy and identify instruments that can trigger changes in consumer behaviour and make circular economy socially acceptable and inclusive, will be essential to accelerate the transition to circular systems for the sustainable management and use of natural resources. R&I solutions will improve knowledge and develop metrics and indicators for measuring material flows, the circular economy and life cycle performance, governance systems to accelerate expansion of circular economy, including models for multi-stakeholder and cross-value chain collaboration, incentives and financing instruments.

Climate change will require adapting water management to increased scarcity and flooding, as a result of more extreme weather events. Improved knowledge about the status of waterbodies and about long-term change in resources are essential for adaptation. Innovative solutions for the restoration of degraded water bodies and water reuse systems contribute to maintaining natural capital. Transparent water allocation systems to satisfy all needs are essential for sustainable resource use. New governance solutions that build on better spatial planning, based on environmental observation, better modelling and inclusion of citizen and economic actors, like insurances, will be essential to support EU water and climate adaptation related policies (in cooperation with cluster 5).

The ecological consequences of imbalances in the nutrient cycles are visible as eutrophication of surface waters and as contamination of sub-surface waters with increasing costs for drinking water provisions. Forest areas are also affected and get lost for the production of animal feed. Nutrient emissions cause also impact on air, biodiversity, climate and soil. A comprehensive EU policy to balance nutrient cycles is not yet very well developed. Research and innovation is needed to look at how the EU could move to living within the safe nutrient planetary boundary. Research and innovation activities related to the nutrient cycle shall include inter alia more sustainable sourcing of nutrients for example from wastes, alternative soil management, and livestock emissions and recovery of recycling of nutrients for different industrial sectors. Analysis of emissions from relevant sectors, nutrient budgets, and key actions to be taken to close nutrient cycles across all environmental media will be developed. Innovation activities may develop and test better governance arrangements through stakeholder involvement for the realisation of a nutrient policy on local and regional levels. Actions to develop and demonstrate systemic solutions for a sustainable management of nutrients flow in Europe will enhance sustainable, inclusive, safe and healthy primary production and food systems.

5. European Partnerships

In the area of Cluster 6 the landscape of Horizon 2020 partnerships is characterised by a high share of public – public partnerships. Among those partnerships, two are institutionalised ones (Bio-Based Industries and PRIMA). With a view to rationalise the landscape, the following eight areas for future partnerships have been identified, The specific nature of some of the identified challenges make partnerships a useful means for implementation. This is notably the case if a structured cooperation with already existing broad stakeholder networks is required to create impact from a strategic research and innovation agenda; or if

partnerships with a network of public R&I funding agencies can create synergies. The following areas for partnerships with centre of gravity in this Cluster are proposed:

- Towards more sustainable farming: agro-ecology living labs and research infrastructures
- European Partnership on Animals and Health
- Environmental Observations for a sustainable EU agriculture (Agriculture of data)
- Rescuing biodiversity to safeguard life on Earth
- A climate neutral, sustainable and productive Blue Economy
- Safe and Sustainable Food Systems for People, Planet & Climate
- European Partnership for a Circular bio-based Europe: sustainable innovation for new local value from waste and biomass
- Water4All: Water security for the planet

EIT Knowledge and Innovation Communities (KICs). In addition to the support to the abovementioned European Partnerships, the Cluster 6 will collaborate with relevant EIT Knowledge and Innovation Communities (KICs). Thanks to their societal challenge-driven approach and their portfolio of activities, ranging from entrepreneurial education and training, to innovation projects, business creation activities and support services for start-ups, scale-ups and SMEs, the EIT KICs, in particular, EIT Climate-KIC and EIT Food, are well equipped to develop synergies and complementarities with Cluster 6 activities. 'Water and maritime' has been proposed a potential theme for a future EIT-KIC and EIT might support in future the KIC in coordinated cross-KIC actions in challenges, like the circular economy, that are so far addresses at the margins of several KICs.

The Standing Committee on Agricultural Research (SCAR) is an established advisory committee for the coordination of research and innovation addressing large parts of this Cluster and has played a key role in identifying R&I orientations in this field for many years. The continued use of the SCAR advisory committee is key to achieving the targeted impacts of Cluster 6.

6. Missions

One of the main novelties of Horizon Europe is the introduction of missions; high-ambition, high-profile initiatives which will put forward concrete solutions to challenges facing European citizens and societies. Missions are currently in the process of being defined within five areas;

- adaptation to climate change including societal transformation
- cancer
- healthy oceans, seas, coastal and inland waters
- climate-neutral and smart cities
- soil health and food

Accomplishing missions will require a cross-cutting approach, drawing on research and innovation activities defined not only through individual Clusters, but across Horizon Europe and beyond. Research and innovation activities within this Cluster thus have the potential to support missions in all of the above-mentioned areas. The synergies between each mission and cluster will be further explored as possible missions take shape.

7. International Cooperation

The EU is party to the UNFCCC[42], to the UNCCD[43] and to the UNCBD[44] ("the Rio Conventions") and has taken commitments under this framework to limit global warming (lastly under the Paris Agreement), to achieve land degradation neutrality and to halt biodiversity loss. In 2015, the EU committed to the 2030 Agenda for Sustainable Development. Through successive Framework Programmes the EU supports and contributes to the work of the IPCC[45] and to the IPBES[46], in terms of providing scientific evidence and science-policy-society interfaces.

At the same time major efforts have been put into strengthening access to environmental observation and data through the Global Earth Observation System of Systems (GEOSS) with the involvement by the European Commission as a co-chair of the Group on Earth Observations (GEO)[47], in order to underpin environmental policies and global commitments (SDGs, Sendai Framework and Paris Agreement).

Global challenges are global in nature and require global commitments. Therefore, international cooperation will be stepped up through strategic alliances in areas, such as food and nutrition security, animal health, soil, climate change, water management, ecosystem restoration or forest management. This will not only involve bilateral cooperation, but also multilateral cooperation, through existing networks, such as the Belmont Forum, the Bio-economy Forum or the establishment of international research consortia[48] (IRCs). The establishment of one IRC is expected in the area of soil and carbon.

The development of an EU-African Union Research and Innovation Partnership will be continued in areas such as food and nutrition security, sustainable agriculture (FNSSA) and climate resilience. The continuation of the partnership FNSSA in Horizon Europe is a response to the level of hunger in Africa, expanding nutritional imbalances, and the need for agriculture and food production systems to sustainably respond to rising demand.

---

[42] UN Framework Convention on Climate Change https://unfccc.int/resource/docs/convkp/conveng.pdf
[43] UN Convention to Combat Desertification https://www.unccd.int/
[44] UN Convention on Biological Diversity https://www.cbd.int/
[45] Intergovernmental Panel on Climate Change https://www.ipcc.ch/
[46] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services https://www.ipbes.net/
[47] GEO Mexico City Declaration; GEO Strategic Plan 2016 - 2025
[48] IRCs are flexible platforms that allow coordination of global efforts in a specific area. The IRC Star-Idaz, supported by Horizon 2020 focuses on animal health.

Cooperation with China as part of the Food, Agriculture and Biotechnology (FAB) task force will continue on priority themes of mutual interest.

International cooperation with Brazil and the wider CELAC region will be encouraged on nature-based solutions, ecosystem restoration and natural capital in order to support relevant EU policies and partnerships, notably addressing the objectives of the UNFCCC, the CBD, the Sendai Framework, Habitat III and the Sustainable Development Goals

Leading international cooperation activities in the field of water will be also promoted with a view of supporting relevant EU policies and partnerships and water diplomacy. Also cooperation for all European sea basins will be key to achieve the strategic objectives for seas and oceans, particularly through the All-Atlantic cooperation and the cooperation for the Mediterranean.

The EU will continue to work with international partners to step up science, research and innovation in all European sea basins to underpin international ocean governance, ensure food supply from the seas and oceans, advance polar science and knowledge on climate variability and predictive capabilities for changes such as sea level rise, and complete sea floor mapping, including habitats. This will include the further implementation of the Galway and Belém Statements, respectively signed with the US and Canada, and Brazil and South Africa with a vision of building an all Atlantic Ocean Community and by also implementing the bilateral Administrative Arrangements on Marine Research and Innovation Cooperation with Argentina and the Republic of Cabo Verde.

In the Mediterranean, marine research and innovation cooperation with a significant number of members of the Union for the Mediterranean will continue through the BLUEMED initiative. At the same time, a Strategic Research and Innovation Agenda for the Black Sea will be implemented, as part of the Common Maritime Strategy for the Black Sea.

The EU (both European Commission and several of the EU Member States) are actively cooperating with international partners within the Organisation for Economic Co-operation and Development (OECD), especially in its Working Party on Biotechnology, Nanotechnology and Converging Technologies (WP BNCT). Among the areas of future cooperation are the bio-based economy solutions, circular urban bioeconomy and sustainability assessment methodologies of bio-based products.