Non-paper

# Horizon Europe

# cluster on

# 'Food, Bioeconomy, Natural resources, Agriculture and Environment'

## - an ocean of opportunities for aquatic science and for developing the blue bioeconomy

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11 April 2019

## Purpose of this document

The main purpose of this document is to provide inspiration for input to Horizon Europe regarding the aquatic research and its relevance for developing the blue bioeconomy.

The take-home message of the paper is, that not only the intervention area on 'seas and oceans' in the Cluster on 'Food, Bioeconomy, Natural resources, Agriculture and Environment', but all the intervention areas in this cluster, should include the aquatic dimension, to address the research and innovation needs related to the transition into a sustainable bioeconomy that preserves and restores the planet's vital natural systems and environment. Granted that the challenges are interlinked a systemic approach is needed. This paper provides a number of examples to illustrate this point.

The hope is that the document can serve as a basis for discussing the scope of the intervention areas in each Member State. If several National Contact Points (NCPs) voice the importance of having aquatic related research integrated in all Intervention areas, such a clear message would have a higher chance of being heard in the Programme Committee.

## Introduction

The outline of the 9th Framework Programme (Horizon Europe proposal, as set out in COM(2018) 436 final) is divided into 3 pillars. Pillar 2 targets 'Global Challenges and Industrial Competitiveness' by boosting key technologies and solutions underpinning EU policies and the Sustainable Development Goals (SDGs). Pillar 2 is subdivided into 5 or 6 clusters one of which is Cluster 'Food, Bioeconomy, Natural resources, Agriculture and Environment' (in this document referred to as *the cluster on food and natural resources*). The proposed budget for this cluster is €10 billion, which will be realised through calls, missions and partnerships.

The rationale behind the *cluster on food and natural resources* revolves around the increasing interlinked pressures on soils, seas and oceans, water, air, biodiversity and other natural resources caused by expanding human activities and a growing global population. It is recognised that nourishing the population dependents on the health of natural systems and resources. Thus emphasis is on further developing sustainable solutions, which provide an opportunity to balance environmental, social and economic goals. Among such solutions are the concepts related to the circular economy, the bioeconomy and the blue economy.

EU's ambitions related to the bioeconomy in general are clearly articulated in the recently updated Bioeconomy Strategy from 2018, where it is stated that a "*circular bioeconomy will boost the competitiveness of the bioeconomy sectors and support the creation of new value chains across Europe*". However in order for the strategy to be truly successful "*the European bioeconomy needs to have sustainability and circularity at its heart*", not only as a legal obligation but as underpinning priority for EU actions and policies.

For the blue bioeconomy, we interpret this as not only complying with the major directives and policies (i.e. Marine Strategy Framework Directive (MSFD), the Marine Spatial Planning Directive (MSPD), the Common Fisheries Policy (CFP), the Habitats Directive and the Blue Growth Strategy) but actively supporting their ambitions and goals behind them.

## From ambitions to targeted activities

To address the goals related to the blue bioeconomy the Bioeconomy strategy emphasizes that Europe will have to rely "*on advances in sciences, technologies and innovations merging the physical, digital and biological worlds, in some of the EU's most significant sectors and industries*". Given that Horizon Europe represents EU's primary strategic R&I tool beyond 2020, it is natural to highlight how the *cluster on food and natural resources* in particular could be used to support the ambitions related to developing the blue bioeconomy.

Seen from a blue bioeconomy perspective the expected activities described in the *cluster on food and natural resources* are ambitious and diverse, and cover a wide range of research disciplines and industries. It is positive to see that:

- The aim is to cover the capacity to observe, and tackle challenges both on land and in sea and oceans, many of which are interlinked.
- It is the aim to provide integrated views, and system-wide solutions that covers the utilisation of resources from both terrestrial and aquatic systems.

Implementation of the activities are structured into seven Intervention Areas, each with a short description and some "Broad Lines" of activities to exemplify the approach in "Annexes to the Proposal for a decision of the European Parliament and of the council" (COM(2018) 436 final).

The 7 intervention areas are:

1. Environmental observation
2. Biodiversity and natural capital
3. Agriculture, forestry and rural areas
4. Sea and oceans
5. Food systems
6. Bio-based innovation systems
7. Circular systems

However, going through the descriptions of the Intervention Areas and the "Broad Lines" of themes/approaches the ambition of supporting activities that can cover both land and aquatic systems – or provide solutions that integrate usage of terrestrial and aquatic resources, is set too low or missing. To support more directly a systemic approach in addressing the *cluster on food and natural resources* more directly, it may therefore be worth dedicating more activities towards the interconnectedness of land and sea use or ensure both systems are addressed in the envisioned activities (true systems thinking).

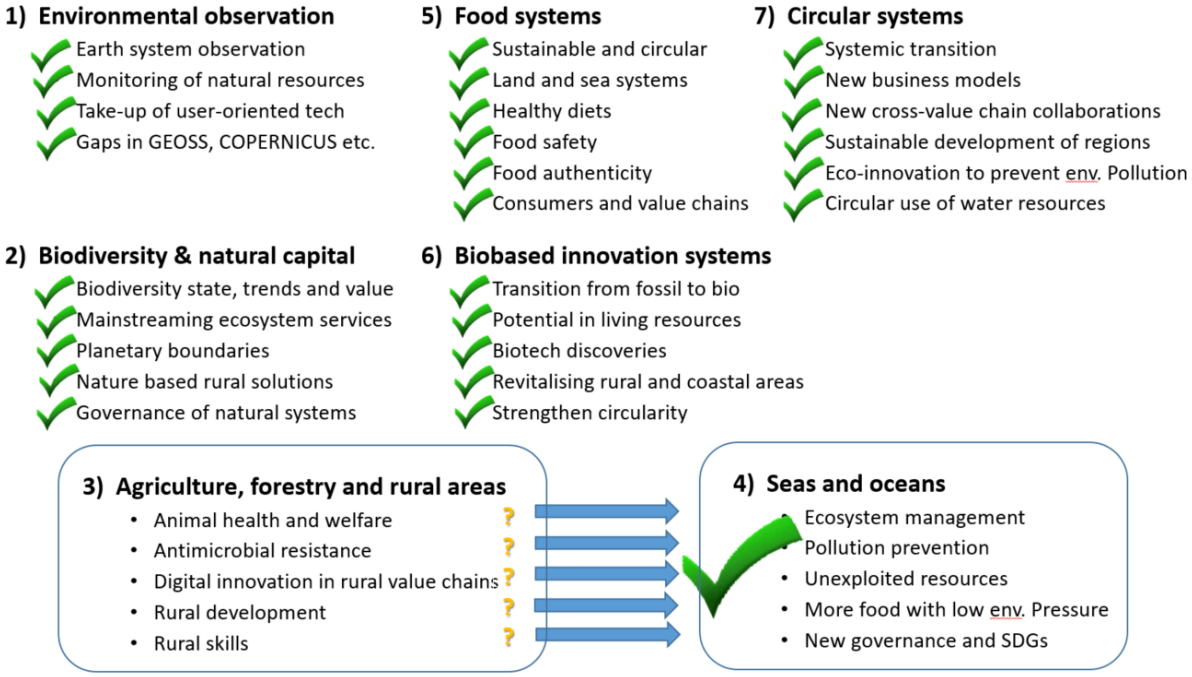
A growing human population, 9.7 billion by 2050 according to United Nations estimates (Béné et al., 2016; SAPEA, 2017), and the expectations of citizens from an increasingly prosperous developing world will intensify the global demand for food (European Commission Scientific Advice Mechanism, 2016). Not only will there be many more people, but today's nutritional challenges (hunger, undernutrition and micronutrient deficiencies), coupled with the expectations of citizens in an increasingly prosperous world, where people are eating more meat and fish in their diets, will intensify the global demand for food and biomass. Given current trends, total food demand is projected to increase by 60% by 2050, according to the Food and Agriculture Organisation of the UN (SAPEA, 2017). This will push conversion of land to crops and pasture as well as putting pressure on freshwater resources that are already in many cases over-exploited and threatened by global warming (European Commission Scientific Advice Mechanism, 2016).

Any additional biomass demand other than for food, such as for bioenergy or feed adds further pressure and their expanded use should be carefully investigated (Conijn et al., 2018). According to the EU Blue Growth strategy (2012) further clearing of forests or draining of wetland or depletion of marine resources and ecosystems will deprive future generations of the benefits they provide. Therefore, we need to look how the ocean, which represents 71% of the planet can deliver human necessities such as food and energy in a way that is more sustainable (Commission of the European Communities, 2012). Following the EU Food 2030 strategy (2016) this should include (next to developments in the sustainable use of land and soil) the sustainable use of marine waters and biodiversity as providers of ecosystem services upon which food production relies (European Commission, 2016).

In Europe currently this consideration on how to sustainably harvest more food from the oceans (European Commission Scientific Advice Mechanism, 2017; SAPEA, 2017) is reflected in such initiatives as the 2012 Blue Growth strategy (Commission of the European Communities, 2012; Bell et al., 2017), the 2014 communication on innovation in the blue economy (Commission of the European Communities, 2014), the 2016 FOOD 2030 initiative (European Commission, 2016a) the 2016 Ocean Governance initiative (European Commission, 2016b) and the initiative of the EU College of Commissioners, led by Commissioner Vella, to request scientific advice in the area of food and biomass from the oceans (European Commission, 2017). Hence there is the necessity and the political will to investigate "How can more food and biomass be obtained from the oceans in a way that does not deprive future generations of their benefits" (European Commission Scientific Advice Mechanism, 2016). Next to this political will, there is of course the necessity to develop the science underpinning and enabling this development.

On land, space and water are becoming scare commodities. Yet our planet consists for 71% of water, with 95% of our water reserve in our oceans and seas. Today we are not using this potential to its fullest. The "green evolution" enabled us to feed the current world-population; a "blue revolution" is needed to feed the world by 2050. This is a revolution as utilising our ocean resources more we need a springboard to develop the necessary innovations rather than an incremental development from current practices.

**The seven intervention areas - and activities relevant to the blue bioeconomy**




Shown above are keywords extracted from the description of each of the seven intervention areas. The green check-marks indicate areas that have an aquatic component, and thus potential to be addressed separately or integrated in a land/sea approach. Intervention area 3 is dedicated to the agriculture and forestry sectors. However, if activities of e.g. animal health and welfare, rural development and skills are restricted to terrestrial animals and farm communities, then similar issues would need to be covered in the intervention area 4 “Seas and oceans” in relation to aquatic organisms (fish, shellfish) and coastal communities.

With this non-paper we wish to provide *examples* (not a comprehensive list nor a priority list) of how all of the *cluster on food and natural resources*’ intervention areas could be used to support the development of the blue bioeconomy.

## Examples of aquatic aspects in each of the seven intervention areas

The broadlines are mentioned in black – examples of aquatic aspects are provided in blue text. We wish to stress that these are only examples to underline the main point and should not be seen as a complete nor prioritised list.

1. **Environmental observation (see the excerpt from the Annex I, 5.2.1)**

Underpinning R&I through Earth Observation for the sustainable use and monitoring of food and natural resources and more broadly the Earth System;

- Marine R&I potentially represent the environmental research area most in need of better observation systems, to support the monitoring and management of earths largest biome.
- Examples include e.g. the large number of data poor fish stocks, poor knowledge of deep-sea resources, and improve our understanding of ecosystem dynamics and the associated challenges of forecasting (e.g. fish, invasive species, sea mammals, ecosystem changes, habitats, weather).
- Observation capacity should widen to cover more biological types of data, including other groups of marine organisms, in addition to the present focus on physical and chemical attributes, and to extend to deep-sea ecosystems.
- Fully use the available observation systems, either in coastal areas or deep sea ecosystems, to effectively regulate harvesting and reduce overfishing, illegal, unreported and unregulated fishing and destructive fishing practices
- Support the development of new technology collecting and organizing information generated by existing monitoring systems contributing to the implementation of monitoring networks.

Deploying, exploiting and up-taking user-oriented technologies and applications;

- Low cost, high quality data may be achieved through remote monitoring and autonomous sampling technology deployed by e.g. fishing vessels or offshore windfarm operators, hereby improving both meteorological as well as oceanographic science and industries' ability to i.e. forecast fish occurrence and abundance, fishing effort, ecosystem changes, weather.

Addressing gaps in Earth Observation through GEOSS and EuroGEOSS, including in support of COPERNICUS products and services.

- In marine and maritime R&I the IOC GOOS and EOOS, represent valuable initiatives which in combination with e.g. EuroGEOSS, are considered the key providers of in situ marineenvironmental earth system information.

2. **Biodiversity and natural capital (see the excerpt from the Annex I, 5.2.2)**

State, value and trends of biodiversity, ecosystems and their services, natural capital and the 'planetary boundaries' & eco-toxicology of new compounds;

- Most marine and coastal natural capital and their associated ecosystem services have never been mapped, allowing very limited ability to value them, assess their state and trends as well as their biosphere integrity, which is a control variable in the planetary boundary framework.
- There remains a strong need to identify how more holistic ecosystem assessments could be implemented in relevant data collection frameworks. Human pressures are a relevant component affecting natural capital and ecosystem services and need to be included in data collection frameworks.

- Nitrogen loads, a planetary boundary which presently has been transgressed, can be mitigated using aquatic production of e.g. mussels and macro algae (e.g. integrated multitrophic aquaculture), hereby additionally providing valuable blue biomass.
- Efforts to address new toxic compounds should take notice of JPI Oceans' recently established Knowledge Hub on "Integrated Assessment of Effects of New Pollutants".
- Characterisation of new compound' ecotoxicology is one of the foundations for sustainable blue bioeconomy.

Mainstreaming biodiversity and ecosystems services in decision making, enhancing the science-policy interface, including in international processes;

- The Marine Strategy Framework Directive and the Marine Spatial Planning Directive already mention ecosystem services, but do not articulate how concerns/data for this are supposed to be integrated into the decision-making processes. It should be a priority to research how these directives together with e.g. the Environmental Impact Assessment Directive, could be developed to support this ambition for the marine environment.
- National and regional coordination with parallel Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem services (IPBES) assessments, should be emphasized especially for the marine environment where data and efforts are lacking. Regional coordination is also a relevant consideration in GES assessments.
- The Blue Economy would benefit from a more systematic assessment about the full range of trade-offs related to spatial planning of e.g. fishing activities, aquaculture, offshore wind farms and recreational uses of the coastal environment.

Nature-based solutions for addressing challenges in cities, rural, marine and coastal areas applying multi-actor living labs approaches.

- Job creation in rural coastal areas could be developed and supported with targeted innovation focusing on new ways of optimizing benefits from marine infrastructure. Examples could be new use for dismissed offshore extraction platforms, or a multi-actor joint eco-engineering of offshore wind farms, which would support both energy production, reef habitat restoration, recreational uses and aquaculture, hereby benefitting both tourism, ecosystem functioning, biodiversity and fisheries/aquaculture.
- Artificial stocking of fish, mussels, algae, lobsters etc., for local consumption and recreational catch along coastlines, lakes and rivers, could create local incentives to maintain a healthy ecosystem while supporting tourism in rural areas involving multiple stakeholders and multidisciplinary research knowledge.

Governance aspects of transition to sustainability – in economic, social and natural systems across scales local to global.

- Areas within EU jurisdiction but outside Europe and areas beyond EU jurisdiction i.e. international waters, represent important areas for parts of EU's marine and maritime sectors due to their richness in biological resources.
- With regard to ocean basin management and scientific advice, regional initiatives and conventions are important players, which should be considered in R&I actions. These are deep-sea ecosystems for which there is a need to intensify data collection and data sharing
- In particular, we need attend to the challenge of establishing an international governance framework to address management and use of natural resources of our oceans in an international context, especially for the international waters and deep seas.

3. **Agriculture, forestry and rural areas (see the excerpt from the Annex I, 5.2.3)**
   The broad line mentions aspects such as animal health and welfare, rural development and skills; all of which apply to the marine environment. But if this intervention area (#3) should

exclusively deal with terrestrial animals and farm communities, then similar issues need to be addressed in intervention area 4 Seas and oceans in relation to aquatic organisms. E.g. Selective breeding, especially of new species of fish, macro and micro algae, hold large potentials for improving the efficiency of land-based aquatic production systems and reducing the risk of diseases due to overcrowding and, consequently, the use of antibiotics and other medicines.

Though the focus of this intervention area is on the agriculture and forestry sector, the interlinkage of resources and impact on ecosystems should be tackled in a holistic manner;

- Sustainable management should take an integrated approach which, acknowledges the land and sea interface, and the potential trade-offs and mitigation options, e.g. in relation to pollution.
- Land-based aquaculture in e.g. recirculation systems, has the potential to become one of the most resource efficient and low impact production systems on land for sustainable food production.

Integrated approaches towards plant pests and diseases; animal health and welfare; tackling antimicrobial resistance and biological and agro-chemical hazards;

- Land-based aquaculture is presently expanding globally, but remains challenged by appropriate feed as well as health and welfare issues. Anti-microbial resistant organisms and genes are now found widespread throughout the environment, including in aquatic and marine environments and pose a serious emerging risk for human health and well-being. Anti-microbial resistant bacteria enter the aquatic ecosystems through effluents from wastewater treatment plants, hospitals, pharmaceutical production and stock farming including aquaculture. Efforts to address this should take stock of the proposed joint ERANET Cofund action between JPI Water, JPI Oceans and JPI Antimicrobial Resistance to address the impacts of new pollutants

Digital innovations in farming, forestry and across value chains in rural areas;

- Digital innovation across value chains in all parts of the bioeconomy, would benefit rural areas. This is equally true for the blue bioeconomy (fisheries and aquaculture) situated in rural coastal regions.

Rural development, skills and Agricultural Knowledge and Innovation Systems (AKIS).

- The expanding use of new technology in the blue part of the agriculture industry, i.e. land-based aquaculture systems, increases the need for human capacity building in rural and coastal production areas.

4. **Sea and oceans (see the excerpt from the Annex I, 5.2.4)**

   There are many documents to consult for specific seas and oceans related research, and with this document we wish to emphasise where marine related challenges are linked to the other intervention areas. Below a few specific themes are mentioned.

Sustainably manage, protect and restore marine and coastal ecosystems and prevent marine pollution;

- Understand the impact of management by carrying out performance analyses of e.g. the CFP and local management plans.
- Advance the mainstreaming of ecosystem-based management, and its benefits for the blue economy as suggested by Atlantic Ocean Research Alliance (AORA), ideally through the integration of an ecosystem service framework to support synergies across EU policies and anticipated R&I actions.

- Improve development of tools supporting marine spatial planning e.g. integrated coastal zone management, location of aquaculture sites, and end to end ecosystem modelling.
- Support uptake of new technologies in monitoring and management of marine and maritime activities, to improve coverage and reduce costs. And benefit from new technologies in other sectors.
- Support development of selective and environmentally friendly fishing gears, stimulating resource efficiency through the reduction of unwanted by-catch that is discarded at sea and minimizing ecosystem impacts, contributing to sustainable and economically efficient fisheries.
- Understand the long-term impact of fisheries and aquaculture on genetic diversity of the wild populations.
- Improve the ability of marine sectors to adapt their production both economically and socially to a changing world, facing an increasing demand for food in a context of climate change.
- Innovations that may foster both ocean business and the ocean environment.
- Assess how and to which extent artificial structures, e.g. harbours, bridges, wind farms etc. can be eco-engineered to restore or enhance ecosystem services like e.g. spawning and nursery grounds, flood protection etc.

Sustainably unlock the vast and unexploited potential of seas and oceans, producing more food, while alleviating pressure on land and fresh water resources;

- Adding value to the presently available blue biomass and waste materials from its value chain, should remain a core ambition, given its global availability and potential for scaling up.
- Multitrophic production is one example of an approach, which could increase the overall biomass production while simultaneously lowering the environmental impact of production.

Partnering approaches and macro-regional strategies, ocean governance and UN Decade of Ocean Science for Sustainable Development.

- Multiple potential partners exist in relation to the marine area, ranging from topic specific Cofunds like the Blue Bioeconomy Cofund, to regional initiatives like the Joint Baltic Sea Research and Development Programme (BONUS), BLUEMED, and pan-European coordinating actors like JPI Oceans.
- The institutional setting of regional management plans, should be developed to ensure long-term sustainability, including cooperation in the Regional Seas with non-EU Member States.
- Governance of Biodiversity Beyond National Jurisdiction (BBNJ) and the development of a UN BBNJ agreement involves many European member states and associated institutions.

5. **Food systems (see the excerpt from the Annex I, 5.2.5)**

   The need to take a food systems approach is supported by several international policy developments including the SDGs and COP21 commitments. The EC has developed the Food 2030 as an R&I Policy Framework to future-proof nutrition& food systems. Taking a food systems approach by necessity requires a holistic and joint effort as demonstrated by the recently launched JPI HDHL with JPI Oceans and FACCE-JPI Knowledge Hub on Food and Nutrition Security.

Food systems transformation – environmentally sustainable, circular and resource efficient food systems from land and sea;

- The transformation of EU's food system into a circular and more productive version, than what is presently available, will become challenging, unless focus includes the potential lying in aquatic production, where e.g. seaweeds, fish and mussel production is a vastly more energy efficient way of producing protein for human consumption than livestock.

- The resilience of aquatic production systems can be particularly high in closed recirculation systems, where all variables are controlled.
- New species and diversification of the food production would support food security.
- The sustainable development, harvesting, processing and marketing of protein-rich feed ingredients based on locally harvested blue biomass, creating local business and employment opportunities, represent an attractive alternative to e.g. South American soy which must be shipped to Europe.

Healthy diets and personalised nutrition;

- Understanding the nutritional value of new and more sustainable feed/ food and ingredients, such as algae could increase the use compared to traditional food products in Europe, which compared to e.g. parts of Asia, has a very low consumption of aquatic food products.

Food safety and authenticity;

- In order to expand the production of food from and in the oceans, increased monitoring and forecasting is necessary of e.g. toxic algae blooms to ensure seafood safety.
- Food safety scandals appear in all areas of the food system, including food from the oceans. Improving supply chain transparency is necessary to ensure consumers trust the authenticity of food products.
- Reinforce and harmonize at European level the current system of control of fish fraud by substitution of species through the implementation of current biomolecular diagnostic methods and genome sequence database.

Consumer behaviour, lifestyle and motivations for better health and environmental sustainability along the food value chain

- In order to move the sustainability agenda forward, consumer behaviour could be reinforced by researching how e.g. sustainability certifications such as Aquaculture Stewardship Council (ASC) and Marine Stewardship Council (MSC) in aquaculture and fisheries, contribute to the EU's own goals, and what additional benefits could be accomplished through branding efforts.
- The allocation of e.g. marine space to production of new types of food, will, in order to secure local and national backing, demand proper public discussions which should be supported by relevant scientific knowledge.
- Further understanding is needed about the impact of global seafood trade on local fisheries, aquaculture, seafood production and economies.
- The general perception of citizens and consumers about the potential use of our oceans' resources, especially in the light of providing the world population in a sustainable way with food, water and energy, has to be considered. The use of our seas is a concept that for a vast majority of the world population today goes beyond comprehension and results in an ill-informed perception of both the potentials and threats of the marine socio-ecological system.

### 6. Bio-based innovation systems (see the excerpt from the Annex I, 5.2.6)

Laying the foundations for the transition away from fossil-based into bio-based materials and products;

- One key example from coastal areas, are the use of algae in e.g. bio-based plastics but many others chemicals can be extracted from marine sources and used in various economic sectors as e.g. cosmetic, chemistry, energy.

Capitalising on the potential of living resources, life sciences and industrial biotechnology for new discoveries, products and processes;

- Adding value to the presently available blue biomass and waste materials from its value chain, should remain a core ambition, given its global availability and potential for scaling up.
- A high potential is expected from large scale production of micro and macro algae, which can be used directly or manipulated to produce valuable bio-based products.

New economic activities and employment to regions, cities and revitalising rural and coastal areas;

- Blue Biomass is primarily produced or landed in rural coastal communities, where they create jobs. Any value adding processing could therefore be deployed at the source, to support local development.
- New economic activities could relate to the non-extraction use of the biomass such as sea safaris or other experience-based activities. E.g. underpinned by activities/structures aimed at increasing the wild blue biomass.

Strengthen the circularity of the bioeconomy.

- Circularity should be understood as a flow of e.g. nutrients, where the proper scale and system boundaries, should depend on the ecosystem and the resources in focus.

**7. Circular systems (see the excerpt from the Annex I, 5.2.7)**

Systemic transition to a resource-efficient and circular economy;

- Use of underexploited resources (e.g. macroalgae), fisheries discards and waste products from processing of marine biomass provides an example of an under-valued resource, which use should be optimised, to fill gaps in the present bioeconomy's demand for e.g. fatty acids, antioxidants and proteins.
- Integrated multi-trophic aquatic production, could provide a very attractive way of increasing production of food and raw materials in a circular ecosystem-based way.
- Circular system could be developed further to turn residual materials into resources for different branches of the industry. Combining the aquatic and agricultural production sectors has such potential. Residual materials from agriculture (*Even forest*) could be used for instance for transformation to aquaculture feed. The nutrition rich residual material from aquaculture could be better developed and used as a fertilizer on land and thereby create regional circular systems.

Metrics, indicators and governance, involving new business models, new products and services, new financing and new multi-stakeholder and cross-value chain collaborations;

- Efforts by the Blue Bioeconomy Cofund will deal with aspects of this in relation to blue biomass, and will as a consequence be able to provide advice on the topic in the coming years.

Sustainable and regenerative development of cities and peri-urban areas and regions;

- Regenerative impacts on coastal marine ecosystems, could be explored as a part of artificial structures and multi-trophic systems aiming at fulfilling importing ecosystem functions.

Eco-innovation for prevention and remediation of environmental pollution;

- To prevent environmental pollution, identification and synthesis of novels chemicals less toxic for marine ecosystems can be a valuable way. The development of novel chemicals that could be used as a biocide in anti-fouling paint is a relevant example.
- To remediate environmental pollution some biochemical flows, such as the nutrient flow from land to coastal areas, can only become a closed loop if nutrients are brought back to land, through e.g. the harvesting of mussels, fish and algae, or fixed in macroalgae.

Circular use of water resources.

- Example of water reuse maybe - To integrate land-based fish farming with hydroponics (cultivating plants in water) to reuse water (also other residues) - aquaponics
- Example of valorisation of wastewater maybe - To clean land-based fish farming water by cultivating there macroalgae and valorisation macroalgae afterwards (in our case we have innovation project where they are using sea water for fish farming and trying to clean the water by cultivating macroalgae as much as it is possible to return the water to the sea).

**Excerpt from the "Annexes to the Proposal for a decision of the European Parliament and of the council" (COM(2018) 436 final) – page 45 to 52:**

## 5. CLUSTER 'FOOD AND NATURAL RESOURCES'

### 5.1. Rationale

Human activities are exerting increasing pressure on soils, seas and oceans, water, air, biodiversity and other natural resources. Nourishing the planet's growing population is directly dependent on the health of natural systems and resources. However, combined with climate change, humanity's growing demand for natural resources creates environmental pressures that go far beyond sustainable levels, affecting ecosystems and their capacity to provide services for human well-being. The concepts of the circular economy, the bioeconomy and the blue economy provide an opportunity to balance environmental, social and economic goals and to set human activities on a path to sustainability.

Meeting the goals of sustainable development, guaranteeing the production and consumption of safe and healthy food, promoting sustainable practices in agriculture, aquaculture, fisheries and forestry, ensuring access to clean water, soil and air for all, cleaning up the seas and oceans, preserving and restoring the planet's vital natural systems and environment requires that we harness the potential of research and innovation. But the pathways for the transition to sustainability and ways to overcome resilient barriers are hardly understood. Making the transition to sustainable consumption and production and restoring planetary health requires investing in technologies, new business models, and social and environmental innovation. This creates new opportunities for a sustainable, resilient, innovative and responsible European economy, boosting resource efficiency, productivity and competitiveness, and generating jobs and growth.

Activities will build a knowledge base and deliver solutions to: sustainably manage and use natural resources from land and sea - and enhance the role of terrestrial and aquatic systems as carbon sinks; ensure food and nutrition security, providing safe, healthy and nutritious diets; accelerate the transition from a fossil-based linear economy to a resource efficient, resilient, low emission, low-carbon circular economy, and supporting the development of a sustainable bio-based economy and the blue economy; and develop resilient and vibrant rural, coastal and urban areas.

They will help to maintain and enhance the provision of biodiversity and secure the long-term provision of ecosystem services, climate adaptation and carbon sequestration (both on land and sea). They will help reduce greenhouse gas (GHG) and other emissions, waste and pollution from primary production (both terrestrial and aquatic), processing, consumption and other human activities. They will trigger investments, supporting the shift towards a circular economy, bioeconomy and blue economy, whilst protecting environmental health and integrity.

They will also foster participatory approaches to research and innovation, including the multi-actor approach and develop knowledge and innovation systems at local, regional, national and European levels. Social innovation with citizens' engagement and trust in innovation will be crucial to encourage new governance, production and consumption patterns.

As these challenges are complex, interlinked and global in nature, activities will follow a systemic approach, cooperating with Member States and international partners, with other funding sources and with other policy initiatives. This will involve user-driven exploitation of environmental big data sources, such as those from Copernicus, EGNOS/Galileo, INSPIRE, EOSC, GEOSS, CEOS, EMODnet.

Research and innovation activities under this Cluster contribute in particular to the implementation of the goals of: the Environmental Action Programme, the Common Agricultural Policy, the Common Fisheries policy, the Food Law legislation, the Maritime policy, the Circular Economy Action Plan, the EU Bioeconomy Strategy, and the 2030 climate and energy framework as well as EU legal provisions to reduce air pollution.

Activities will contribute directly to the following Sustainable Development Goals (SDGs) in particular: SDG 2 – Zero Hunger; SD 6 - Clean Water and Sanitation; SDG 11 – Sustainable Cities and Communities; SDG 12 - Responsible Consumption and Production; SDG 13 – Climate Action; SDG 14 – Life Below Water; SDG 15 - Life on Land.

**5.2. Areas of intervention**

**5.2.1. Environmental Observation**

The capacity to observe the environment underpins research and innovation for the sustainable use and monitoring of food and natural resources. Improved spatio-temporal coverage and sampling intervals at reduced cost, as well as big data access and integration from multiple sources provide new ways to monitor, understand and predict the Earth system. There is a need for a wider deployment, exploitation and update of new technologies and continued research and innovation to address gaps in Earth Observation (EO) on land and sea and in the atmosphere, collaborating in particular through the Global Earth Observation System of Systems (GEOSS) and its European component EuroGEOSS.

*Broad Lines*

– User driven and systemic approaches including open data, to environmental data and information for complex modelling and predictive systems;

– Extension of the Copernicus product and service portfolio;

– Biodiversity status, ecosystem protection, climate mitigation and adaptation, food security, agriculture and forestry, land use and land use change, urban and peri-urban development, natural resources management, ocean exploitation and conservation, maritime security, and other relevant domains;

– User oriented applications including their scaling up, to contribute to the management of European natural resources and ecosystems services and their related value chain.

**5.2.2. Biodiversity and Natural Capital**

Improved understanding of biodiversity and ecosystems, the multiple services they provide and planetary 'boundaries' as well as solutions harnessing nature’s power and complexity is needed to address societal challenges, to enhance sustainability and to attain the EU objective of 'Living well within the limits of our planet' by 2050 as laid down in the 7th EU Environmental Action Programme. Due account must be taken throughout whole value chains of potential upstream impacts. International cooperation and contribution to international efforts and initiatives, such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, are essential to achieve the objectives in this area. There is a need to better understand the governance of the transition to sustainability in the economic, social and natural system, from the local to the global level.

*Broad Lines*

– The state and value of biodiversity, terrestrial and marine ecosystems, natural capital and ecosystem services;

– Holistic and systemic approaches within a socio-ecological framework for the links between biodiversity, ecosystems and ecosystems services and their causality relationships with drivers of change, across different scales and economic activities, including the governance of transition processes to sustainability;

– Modelling of trends and integrated scenarios for biodiversity, ecosystem services and good quality of life at different scales and horizons; the potential contribution of biotopes and ecosystems as carbon sinks under various climate change scenarios;

– Ecotoxicology of compounds and new pollutants, their interactions and environmental behaviour, and altered biochemical loops under changing climate;

– Mainstreaming biodiversity and ecosystem services in decision-making frameworks and accounting systems of governments and businesses, as well as quantification of their benefits;

– Adaptable and multi-functional nature-based solutions, addressing challenges in cities, rural and coastal areas related to climate change, natural disasters, biodiversity loss, ecosystem degradation, pollution, and citizens' health and well-being;
– Multi-actor living labs approaches engaging authorities, stakeholders, business and civil society in co-designing and co-creating systemic solutions for the preservation, restoration and sustainable use of natural capital the governance of the transition to sustainability and sustainable management options in economic activities throughout whole value loops.

**5.2.3. Agriculture, Forestry and Rural Areas**

Resilient and sustainable farming and forestry systems provide economic, environmental and social benefits in a changing context for primary production. In addition to contributing to food and nutrition security, they feed into dynamic value chains, manage land and natural resources as well as deliver a range of vital public goods including carbon sequestration, biodiversity preservation, pollination and public health. Integrated approaches are needed to promote the multiple functions of agro- and forest (eco)systems taking into account the changing context for primary production, notably in relation to climate and environment, resource availability, demography and consumption patterns. It is also necessary to address the spatial and socio-economic dimension of agriculture and forestry activities and mobilise the potential of rural areas.

*Broad Lines*

– Methods, technologies and tools for sustainable and resilient production in farming and forestry;
– Sustainable management and efficient use of natural resources (e.g. soils, water, nutrients and biodiversity including genetic resources) in agriculture and forestry; alternatives to fossil-based resources and adoption of circular economy principles;
– Climate and environmental impact of activities in the primary sector; potential of agriculture and forestry as carbon sinks and for mitigation of greenhouse gas emissions including negative emissions approaches;
– Plant pests and diseases and animal health and welfare; alternatives to the use of contentious pesticides, antibiotics and other substances;
– Antimicrobial resistance and threats from biological and agrochemical hazards as well as chemical contaminants tackling the links between plant, animal , ecosystems and public health from One-Health and Global-Health perspectives;
– The use and delivery of ecosystems services in agriculture and forestry systems applying ecological approaches and testing nature-based solutions from farm to landscape levels for an environmentally friendly agriculture;
– Agricultural and forestry systems from farm to landscape levels; the use and delivery of ecosystem services in primary production;
– Innovations in farming at the interfaces between agriculture, aquaculture and forestry and in urban areas;
– Land use, rural development and territorial linkages; capitalising on the social, cultural, economic and environmental assets of rural areas for new services, business models, value chains and public goods;
– Digital innovations in farming, forestry and across value chains and rural areas through the use of data and development of infrastructures, technologies and governance models;
– Agricultural knowledge and innovation systems and their interconnection at various scales; advice, building skills and information sharing.

**5.2.4. Sea and Oceans**

Seas and oceans' natural capital and ecosystem services offer significant socio-economic and welfare benefits. This potential is at risk because of the severe pressure from human and natural stressors such as pollution, overfishing, climate change, sea-level rise and extreme weather events. To prevent seas and oceans from reaching a point of no return, it is necessary to strengthen our knowledge and understanding in order to sustainably manage, protect and restore marine and coastal ecosystems

and prevent marine pollution, in a context of an improved and responsible ocean governance framework. This will also include research to sustainably unlock the vast and unexploited economic potential of seas and oceans aiming at producing more food without increasing pressures on them, and also contribute to alleviate pressure on land, freshwater and ocean resources. There is a need for partnering approaches, including sea basin and macro-regional strategies, extending beyond the EU (e.g. in the Mediterranean, the Baltic, the Black Sea, the Atlantic, the Caribbean Sea and in the Indian Ocean); and for contributing to International Ocean Governance commitments, initiatives like the United Nations Decade of Ocean Science for Sustainable Development and commitments linked to the conservation of marine biological diversity in areas beyond national jurisdiction.

*Broad Lines*

– Sustainable sea and ocean farming, fisheries and mariculture for food, including alternative sources of protein with increased food security, food sovereignty and climate resilience;

– Strengthened resilience of marine ecosystems thereby ensuring seas and ocean health, combating and mitigating the effects of natural and human pressures like pollution and plastics, eutrophication, acidification, seas and oceans warming, sea level rise, considering the intersection between land and sea and fostering a circular approach;

– Ocean governance at global and regional levels to ensure conservation and sustainable use of the seas and oceans resources;

– Technologies for the digital ocean (seafloor, water column and water surface) connecting services and communities in land-based, climate, space and weather related activities, and promoted through the Blue Cloud as part of the European Open Science Cloud;

– Monitoring and predictive/forecasting capacities including sea-level rise and other natural hazards e.g. storms surges, tsunamis;

– Blue value-chains, the multiple-use of marine space and growth of the renewable energy sector from seas and oceans, including sustainable micro- and macro- algae;

– Nature-based solutions based on marine and coastal ecosystem dynamics, biodiversity and multiple ecosystem services, which will enable systemic approaches to sustainably use the resources of seas and oceans, contribute to environmental protection, coastal management, and adaptation to climate change;

– Blue innovation including in the blue and digital economies, across coastline areas, coastal cities and ports in order to strengthen resilience of coastal areas and increase citizens' benefits.

– Better understanding of the role of oceans for climate change mitigation and adaptation.

**5.2.5. Food Systems**

The combined effects of population growth, resource scarcity and overexploitation, environmental degradation, climate change and migration create unprecedented challenges which require food system transformation (FOOD 2030). Current food production and consumption are largely unsustainable while we are confronted with the double burden of malnutrition, characterised by the coexistence of undernutrition and obesity. Future food systems need to deliver sufficient safe, healthy and quality food for all, underpinned by resource efficiency, sustainability (including the reduction of GHG emissions, pollution and waste production), linking land and sea, reducing food waste, enhancing food production from the seas and oceans and encompassing the entire 'food value chain' from producers to consumers – and back again. This needs to go hand in hand with development of the food safety system of the future and the design, development and delivery of tools, technologies and digital solutions that provide significant benefits for consumers and improve the competitiveness and sustainability of the food value chain. Furthermore, there is a need to foster behavioural changes in food consumption and production patterns as well as to engage primary producers, industry (including SMEs), retailers, food service sectors, consumers, and public services.

*Broad Lines*

– Sustainable and healthy diets for people's well-being across their lifespan;

– Personalised nutrition especially for vulnerable groups, to mitigate the risk factors for diet-related and non-communicable diseases;

– Consumers' behaviour, lifestyle and motivations, promoting social innovation and societal engagement for better health and environmental sustainability throughout the entire food value chain;
– Modern food safety and authenticity systems, enhancing consumer confidence in the food system;
– Food system mitigation of and adaptation to climate change, including the exploration of the potential and use of the microbiome, forgotten crops, alternative proteins;
– Environmentally sustainable, circular and resource efficient food systems from land and sea, towards zero food waste throughout the entire food system, through reuse of food and biomass, recycling of food waste, new food packaging, demand for tailored and local food;
– Innovation and food systems for place-based innovation and empowerment of communities, fostering fair trade and pricing, inclusiveness and sustainability through partnerships between industry, local authorities, researchers and society.

**5.2.6. Bio-based Innovation Systems**

Bio-based innovation lays the foundations for the transition away from a fossil-based economy by encompassing the sustainable sourcing, industrial processing and conversion of biomass from land and sea into bio-based materials and products. It also capitalises on the potential of living resources, life sciences and industrial biotechnology for new discoveries, products and processes. Bio-based innovation, including technologies, can bring new economic activities and employment to regions and cities, contribute to revitalising rural and coastal economies and strengthen the circularity of the bioeconomy.

*Broad Lines*

– Sustainable biomass sourcing and production systems, focusing on high-value applications and uses, social and environmental sustainability, impact on climate and biodiversity reduction targets and overall resource efficiency;
– Life sciences and their convergence with digital technologies for prospecting, understanding and sustainably use biological resources;
– Bio-based value chains, materials, including bio-inspired materials, products and processes with novel qualities, functionalities and improved sustainability (including reducing greenhouse gases emissions), fostering the development of advanced biorefineries using a wider range of biomass;
– Biotechnology, including cross sectoral cutting-edge biotechnology, for application in competitive, sustainable and novel industrial processes, environmental services and consumer products10;
– Circularity of the bio-based economy through technological, systemic, social and business model innovation to radically increase the value generated per unit of biological resources, keeping the value of such resources in the economy for longer and supporting the principle of the cascading use of sustainable biomass through research and innovation;
– Inclusive bioeconomy patterns with different actors participating in the creation of value, maximising societal impact.
– Increased understanding of the boundaries of the bio-based economy and its synergies and trade-offs with a healthy environment.

**5.2.7. Circular Systems**

Circular production and consumption systems will provide benefits to the European economy by reducing resource dependency and increasing the competitiveness of enterprises, and to European citizens by creating new job opportunities and reducing pressures on the environment and climate. Beyond industrial transformation, the transition to a low-emission, resource efficient and circular economy will also need a broader system shift that requires systemic eco-innovative solutions, new business models, markets and investments, enabling infrastructure, social innovation changes in consumer behaviour, and governance models stimulating multi-stakeholder collaboration to ensure that the intended system change achieves better economic, environmental and social outcomes11. Opening for international cooperation will be important for comparability, generating and sharing

knowledge and avoiding duplication of efforts, e.g. through international initiatives such as the International Resource Panel.

*Broad Lines*

– Systemic transition to a resource-efficient and circular economy, with new paradigms in consumer interaction, new business models for resource efficiency and environmental performance; products and services stimulating resource efficiency during the whole lifecycle; systems for sharing, reuse, repair, remanufacturing, recycling and composting;

– Metrics and indicators for measuring the circular economy and life cycle performance; governance systems which accelerate expansion of the circular economy and resource efficiency while creating markets for secondary materials; multi-stakeholder and cross-value chain collaboration; instruments for investment in the circular economy;

– Solutions for sustainable and regenerative development of cities, peri-urban areas and regions, integrating the circular economy transformation with nature-based solutions, technological, digital, social, cultural and territorial governance innovations;

– Eco-innovation for prevention and remediation of environmental pollution from hazardous substances and chemicals of emerging concern; looking also at the interface between chemicals, products and waste;

– Circular use of water resources, including reduction of water demand, prevention of losses, water reuse, recycling and valorisation of wastewater and governance models for smart water allocation, addressing sources of pollution and tackling other pressures on water resources.

**Presentation to Programme Committee – October 2018**

## CLUSTER 5: Food and natural resources: intervention areas in key words

### Environmental observation (SP Annex I, 5.2.1)

- Underpinning R&I through Earth Observation for the sustainable use and monitoring of food and natural resources and more broadly the Earth System;
- Deploying, exploiting and up taking user-oriented technologies and applications;
- Addressing gaps in Earth Observation through GEOSS and EuroGEOSS, including in support of COPERNICUS products and services.

European Commission

## CLUSTER 5: Food and natural resources: intervention areas in key words

### Biodiversity and natural capital (SP Annex I, 5.2.2)

- State, value and trends of biodiversity, ecosystems and their services, natural capital and the 'planetary boundaries' & eco-toxicology of new compounds;
- Mainstreaming biodiversity and ecosystems services in decision making, enhancing the science-policy interface, including in international processes;
- Nature-based solutions for addressing challenges in cities, rural, marine and coastal areas applying multi-actor living labs approaches.
- Governance aspects of transition to sustainability – in economic, social and natural systems across scales local to global.

European Commission

## CLUSTER 5: Food and natural resources: intervention areas in key words

### Agriculture, forestry and rural areas (SP Annex I, 5.2.3)

- Sustainable management of land and efficient use of natural resources (e.g. soils, water, nutrients and biodiversity including genetic resources);
- Diverse and resilient production systems using and delivering a range of ecosystems services; the potential of agriculture and forestry as carbon sinks;
- Integrated approaches towards plant pests and diseases; animal health and welfare; tackling antimicrobial resistance and biological and agro-chemical hazards;
- Digital innovations in farming, forestry and across value chains in rural areas;
- Rural development, skills and Agricultural Knowledge and Innovation Systems (AKIS).

European Commission

## CLUSTER 5: Food and natural resources: intervention areas in key words

### Sea and oceans (SP Annex I, 5.2.4)

- Sustainably manage, protect and restore marine and coastal ecosystems and prevent marine pollution;
- Sustainably unlock the vast and unexploited potential of seas and oceans, producing more food, while alleviating pressure on land and fresh water resources;
- Partnering approaches and macro-regional strategies, ocean governance and UN Decade of Ocean Science for Sustainable Development.

European Commission

## CLUSTER 5: Food and natural resources: intervention areas in key words

### Food systems (SP Annex I, 5.2.5)

- Food systems transformation – environmentally sustainable, circular and resource efficient food systems from land and sea;
- Healthy diets and personalised nutrition;
- Food safety and authenticity;
- Consumer behaviour, lifestyle and motivations for better health and environmental sustainability along the food value chain

European Commission

## CLUSTER 5: Food and natural resources: intervention areas in key words

### Bio-based innovation systems (SP Annex I, 5.2.6)

- Laying the foundations for the transition away from fossil-based into bio-based materials and products;
- Capitalising on the potential of living resources, life sciences and industrial biotechnology for new discoveries, products and processes;
- New economic activities and employment to regions, cities and revitalising rural and coastal areas;
- Strenghten the circularity of the bioeconomy.

European Commission

# CLUSTER 5: Food and natural resources: intervention areas in key words

## Circular systems (SP Annex I, 5.2.7)

- Systemic transition to a resource-efficient and circular economy;
- Metrics, indicators and governance, involving new business models, new products and services, new financing and new multi-stakeholder and cross-value chain collaborations;
- Sustainable and regenerative development of cities and peri-urban areas and regions;
- Eco-innovation for prevention and remediation of environmental pollution;
- Circular use of water resources.