EU CIRCULAR COOPERATION HUB

# STRATEGIC RESEARCH AND INNOVATION AGENDA ON CIRCULAR ECONOMY

## SEPTEMBER 2020

Developed by CICERONE

# ABOUT US

Developed within the H2020 CICERONE project, the EU Circular Cooperation Hub is a new platform to help stimulate collaboration opportunities, such as joint programming, between programme owners (i.e. institutions that fund and design circular economy related activities). The platform will provide a space for co-design, networking and strategic alignment to support national, regional and local governments in their implementation of joint circular economy programmes.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 820707.

# MISSION

CICERONE aims to bring national, regional and local governments together to jointly tackle the circular economy transition needed to reach net-zero carbon emissions and meet the targets set in the Paris Agreement and EU Green Deal. This document represents one of the key outcomes of the project: a Strategic Research & Innovation Agenda (SRIA) for Europe, to support owners and funders of circular economy programmes in aligning priorities and approaching the circular economy transition in a systemic way.

# ACKNOWLEDGEMENTS


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The production of this document would have been impossible without the dedicated and tireless work by hundreds of stakeholders with various backgrounds across Europe and beyond. Their contributions throughout the consultation rounds and workshops provided us with valuable inputs and perspective. We would like to take this opportunity to express our gratitude and hope that we will continue to work together to advance the transition towards a circular economy.

This is a living document, any revisions will be published online.

# EXECUTIVE SUMMARY

The global economy of today is still based on a linear approach with a focus on exploiting cheap natural resources and managing economies of scale in manufacturing processes. But this is changing, as the interest and ambition to transform global production and consumption systems towards the circular economy continue to grow. Circular economy prioritises resource efficiency and retaining the value of materials and products throughout their entire life cycle, with increased focus on value-chain actors, citizens and other socio-economic aspects. This new way of managing the economy and resources has a significant potential to create positive impact.

To tackle the complex challenge of shifting towards a productive circular economy in the European Union (EU), the European Green Deal was formed in 2019 as a growth strategy to ensure that economic growth is decoupled from resource use while aiming for zero net emissions of greenhouse gases in 2050. At the same time, the second version of the EU Circular Economy Action Plan (EU CEAP) was released in spring of 2020 to encourage societal transformation towards the circular economy, which is also part of the EU Green Deal. Numerous other EU initiatives, including the new Horizon Europe programme, are also increasingly focusing on circular economy-related topics.

Public funding is an important source of financing for Circular Economy (CE) oriented research and innovation (R&I) programmes at both national, regional and European levels. However, circular economy is often not directly addressed or defined in funding programmes – with many focusing on specific impacts, for example *waste reduction and resource efficiency*, which does not consider circular economy in a systemic way. Furthermore, funding often occurs on a highly technical level, targeting specific aspects of the value chain rather than through the lens of systemic change with the involvement of multiple stakeholder groups and citizens - this is slowly shifting, but significant upscaling is needed to increase impact.

### System change can boost resilience against crises

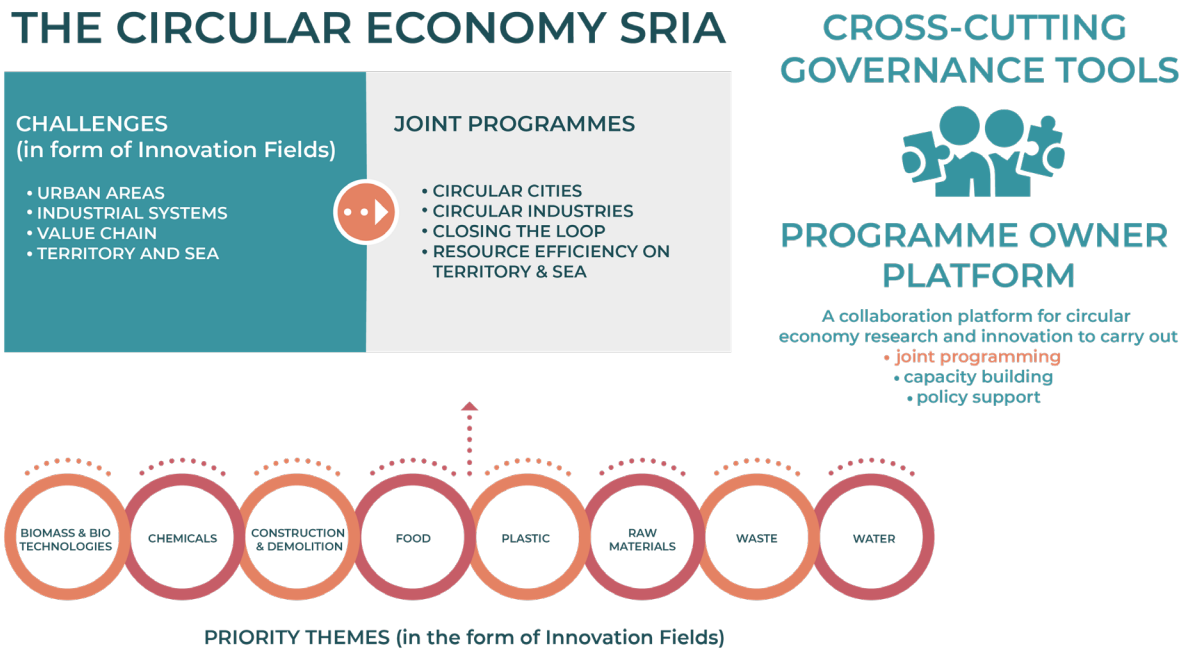
Switching to a circular economy means changing the entire system we live and operate in – and this will not be achieved through single-point interventions. Systemic change means shifting both the function and structure of a system and sustaining change overtime through programmatic intervention.

The global COVID-19 crisis has exposed fundamental flaws in current economic and resource systems. Circular economy can boost the EU's resilience against similar future crises by securing material supply, decoupling environmental degradation from economic growth and reducing the dependency on material consumption as the means to socioeconomic prosperity.

The EU Horizon 2020 CICERONE project (2018-2021)[1] is developing a platform for EU programme owners (POs, i.e. public funders of programmes related to circular economy) to coordinate and collaborate on priority research and innovation actions. Part of this process was the development of the Circular Economy Strategic Research and Innovation Agenda (SRIA). This SRIA is as a strategic guidance document that specifically focuses on the topic of CE in the European Union. The SRIA targets national, regional and local programme owners to identify joint priorities in research and innovation, co-implement joint programmes and guide further cooperation. Collaboration will be based on the SRIA's joint programmes, which provide a framework for a more systemic innovation aiming to create holistic, cross-cutting and systemic programmes with greater impacts.

The SRIA was developed based on eight **priority themes** (*biomass and biotechnologies, chemicals, construction and demolition, food, plastic, raw materials, waste and water*). The themes build on four societal areas that face sustainability **challenges** (urban areas, industrial systems, value chains and territory and sea) to identify priority areas for CE research and innovation (aka. **Innovation fields**) that tackle EU region-wide issues and facilitate the circular economy transition. Based on the innovation fields, four **joint programmes** were developed in this SRIA: 1) Circular Cities, 2) Circular Industries, 3) Closing the Loop and 4) Resource Efficiency on Territory & Sea (see the figure below).

[1] More information can be found on the CICERONE website: http://cicerone-h2020.eu/




**The Circular Economy SRIA was developed by identifying innovation fields across eight themes and four societal challenge areas, out of which four joint programmes were formed. Members of the programme owner platform are foreseen to use both the joint programmes and innovation fields to collaborate on circular economy programming. These aspects of the SRIA can also be tailored to their needs.**

The SRIA aligns closely with major EU strategic documents and policies, such as the European Green Deal and the Circular Economy Action Plan.

Contributing, rather than duplicating, the ambitions and efforts of European strategies and initiatives is a central tenet of the four joint programmes. In this way, the SRIA provides deep added value not only by providing a basis for programme owners to join forces working on circular economy research and innovation, but also in contributing to sustainable socioeconomic development in the EU.

The joint programmes are composed of relevant circular economy objectives and the research and innovation activities needed to achieve them. Each of the joint programmes contain a pilot joint call and a pilot project, which serve as examples of how the SRIA could be used by programme owners to carry out joint programming, and how the potential projects could look like. Overall, the SRIA will be used by programme owners of the platform to collaborate and implement research and innovation actions. Such collaboration can contribute to the acceleration of the EU's systemic transition to the circular economy.

As key priorities, issues, targets and strategies are changing on the ongoing basis, the SRIA's elements are intended to be updated or the new ones to be developed when SRIA will be used for future cooperation throughout the platform developed within CICERONE. The detailed methodology joint programme development is included in the SRIA and could serve as a reference for the future updating and development.

An overview of the joint programmes, including their respective objectives, subprogrammes and activities is presented below.

## CIRCULAR CITIES

Achieving the vision of a circular society requires rethinking how we use different products, services and materials and how to find new ways of creating value while addressing the urban challenges of today. The Circular Cities subprogramme complements major strategies and initiatives related to sustainable urban development (e.g. JPI Urban Europe, EU Green Deal, EU CEAP) to create systemic change from the circular economy perspective, especially in the areas of creating closer engagement and involvement of urban citizens and enhancing the circularity of resources, materials and products. In this regard, the goal of this joint programme is to facilitate and promote the transition to circular economy in urban areas in line with existing sustainable urban development initiatives.

### OBJECTIVE A: TO ENABLE URBAN CIRCULARITY AND INCREASING CITIZEN ENGAGEMENT IN CIRCULAR SOLUTIONS

| Subprogrammes | Activity name and description |
|---|---|
| A1 Infrastructure to enable circular material and product flows | *A1.1 Technical development and digitalisation of waste systems*<br>*A1.2 Improved collection systems for reuse, remanufacturing and sharing*<br>*A1.3 Planning and design for reuse and recycling* |
| A2 Citizen participation in circular material and product flows | *A2.1 Analysis of the current situation on inefficiencies and opportunities for waste collection and recycling*<br>*A2.2 Coordination and implementation of citizen engagement in waste sorting and collection for target waste streams*<br>*A2.3 Analysis of social and behavioural barriers for consumers and citizens for systemic transition to circular economy*<br>*A2.4 Coordination to scale up existing repair and reuse stations (physical and digital)*<br>*A2.5 Product design that facilitates use-life extension and consumer involvement*<br>*A2.6 Development of innovative inclusive governance approaches on citizen participation* |
| A3 Enhancing material efficiency and circular flows in the food and food packaging sector | *A3.1 Review of packaging-free and reduced packaging businesses and good practices/cases*<br>*A3.2 Analysis of new future-proof food and nutrition concepts from the resource efficiency and food security perspective*<br>*A3.3 Upscaling recommercialisation and valorisation of commercial and agricultural food waste*<br>*A3.4 Coordination to scale up recycled/reusable food packaging and packaging-free/ reduced packaging (where appropriate)* |

## OBJECTIVE B: TO ENHANCE CIRCULAR ECONOMY AND NATURAL RESOURCE MANAGEMENT IN URBAN AREAS

| Subprogrammes | Activity name and description |
|---|---|
| B1 Circular economy considerations of water and soil in food systems | *B1.1 Scaling up organic waste collection, diversion from landfills and reuse for energy and food production (soil nutrient cycling and replenishment)*<br>*B1.2 Scaling up wastewater recovery and recycling for irrigation and food production*<br>*B1.3 Mapping of food systems in the EU to identify opportunities for circularity* |
| B2 Circular economy in land and soil resources in construction and urban planning | *B2.1 Overcoming barriers to scale up brownfield development and land reuse*<br>*B.2.2 Scaling up of reusing private and public spaces*<br>*B2.3 Circular economy in urban transport systems*<br>*B2.4 Urban farming to provide ecosystem services, food, water storage and cooling, climate mitigation/adaptation*<br>*B2.5 Historical cultural heritage and natural capital enhancement* |
| B3 Circular economy considerations in water supply and treatment systems | *B3.1 Market introduction of existing pilots and demonstration initiatives on water cascading, wastewater reuse and nutrient recycling*<br>*B3.2 Water type separation and infrastructural changes to water supply and treatment systems* |
| B4 Shifting towards circular water systems in buildings | *B4.1 Review of integrated water resource management (IWRM) and innovative water efficiency cases in commercial and residential buildings*<br>*B4.2 Engaging citizens in scaling up integrated water management in buildings/local level*<br>*B4.3 Engagement of citizens in integrated water resources management in new urban development* |

## CIRCULAR INDUSTRIES

This joint programme focuses on the development of new integrated solutions and the upscaling of existing tools and solutions that already exist at small scale, to be implemented in factories, industrial areas and productive sectors (e.g. agro-industry, metallurgy and textiles, amongst others). This is strongly in line with The EU Green Deal which identifies disruptive innovative technologies a key part of the long-term path to sustainable growth. In this regard, the goal of this joint programme is to facilitate the transition of industries to the circular economy through research and innovation.

The activities identified in this joint programme concern innovation in product design, production processes, the efficient use and management of resources, reduction of emissions and waste, valorisation of process waste, collaborative exchange between different industries and cross-sector collaboration (e.g. through industrial symbiosis), sustainable and circular management of industrial areas, redevelopment of industrial areas and the conversion of existing factories to the circular economy.

### OBJECTIVE A: TO DEVELOP NEW TECHNOLOGIES, QUALITY STANDARDS AND ANALYTIC METHODS FOR NEW MATERIALS PRODUCTION AND RESOURCE AND WASTE CHARACTERISATION

| Subprogrammes | Activity name and description |
|---|---|
| A1 Developing new technologies for new materials production | *A1.1 Water type separation and infrastructural changes to water supply and treatment systems*<br>*A1.2 Pilot, demonstration and upscaling of innovative biotechnological processes for chemicals production*<br>*A1.3 Development of innovative biotechnological processes for plastics production*<br>*A1.4 Pilot, demonstration and upscaling of innovative biotechnological processes for plastics production*<br>*A1.5 Developing processes and eco-design to substitute hazardous substances*<br>*A1.6 Pilot, demonstration and upscaling of hazardous substance management in new materials production* |
| A2 Developing quality standards and analytic methods for materials production and characterisation | *A2.1 Promotion of traceability*<br>*A2.2 Chemical footprint considerations at the front end of business innovation*<br>*A2.3 Developing non-destructive analytical methods to achieve better knowledge of materials composition and properties*<br>*A2.4 Upscaling the use of new analytical techniques and instruments for characterisation*<br>*A2.5 Expansion of extended producer responsibility systems to other sectors* |
| A3 Developing new technologies for resource and waste characterisation | *A3.1 Upscaling systems for widescale secondary raw material use*<br>*A3.2 R&D in analytical chemistry and in electronics focused on instrumental analysis*<br>*A3.3 Development of cost-efficient extractive and processing technologies for improved separation of by-products of ore mining in the EU within the supply chain of materials in CE*<br>*A3.4 Scale up the use of new analytical instrumental technique for characterisation*<br>*A3.5 New agile processing technologies that adaptively operate within a robust smelter system* |

## OBJECTIVE B: TO ENABLE INDUSTRIAL SYMBIOSIS NETWORKS AND FOSTER DIGITALISATION TO MASTER THE COMPLEXITY OF PRODUCTS, PROCESSES AND SYSTEMS

| Subprogrammes | Activity name and description |
|---|---|
| B1 Smart Factories - Building SME partnerships, "alliances of interests" and industrial symbiosis networks | *B1.1 Efficient secondary resources information sharing*<br>*B1.2 Digitalisation of SMEs for circular economy*<br>*B1.3 Development of infrastructure and facilities to upscale industrial symbiosis* |

## OBJECTIVE C: TO RAISE AWARENESS OF INDUSTRIAL ECOLOGY BY PROMOTING NEW/ BETTER DESIGN AND USE OF PRODUCTS AND BETTER RE-USE OF MATERIALS ALREADY IN CIRCULATION

| Subprogrammes | Activity name and description |
|---|---|
| C1 Promoting eco-design and eco-processes | *C1.1 Eco-design and processes that minimise product environmental impact*<br>*C1.2 Upscaling of production based on renewable sources*<br>*C1.3 Advanced remanufacturing processes for safe and efficient material recovery* |
| C2 Promoting re-use, repair and remanufacturing | *C2.1 Development of reverse logistics systems*<br>*C2.2 Standardisation of components*<br>*C2.3 Advanced remanufacturing processes for safe and efficient material recovery* |

## OBJECTIVE D: TO REDUCE THE CARBON EMISSIONS OF COMPANIES

| Subprogrammes | Activity name and description |
|---|---|
| D1 Greenhouse gas accounting and management system (individual company*) | *D1.1 Development of GHG accounting or inventory systems*<br>*D1.2 Development of GHG management systems* |
| D2 Promoting secondary raw materials market and industry | *D2.1 Technologies for e-waste dismantling, separation and recycling*<br>*D2.2 Establishment of secondary market platforms for product reuse*<br>*D2.3 Improvement of e-waste collection infrastructure*<br>*D2.4 Separation technologies for food contact plastic*<br>*D2.5 Establishment of secondary market platforms for raw materials* |
| D3 Reducing the carbon and GHG emissions in industrial systems | *D3.1 Promote the adoption of simulation and modelling tool for assessing carbon footprint*<br>*D3.2 Upscaling energy use efficiency measures*<br>*D3.3 Foster renewable power source*<br>*D3.4 Develop technologies for capturing, storage and disposal of GHG*<br>*D3.5 Promotion of $CO_2$ utilisation technologies* |

## CLOSING THE LOOP

Closing the loop in production and manufacturing is a key factor to promote the transition to a circular economy, in line with the new EU CEAP. This is relevant for both materials (e.g. critical raw materials) and products (e.g. plastic packaging, WEEE and tyres), as well as in specific supply chains (e.g. buildings, agro-industry, textiles). This joint programme focuses on the implementation of synergic actions at macro level involving all the actors of the value chain (designer, producer, distributor, user, end-of-life manager, recycler) in order to identify barriers and remove bottlenecks and broken rings hindering the closure of production loops and implement a sustainable system for all the actors involved. Private actors are also of high relevance.

### OBJECTIVE A: TO ENSURE THAT THE MANUFACTURING PARTNERSHIPS IN HORIZON EUROPE FOCUS ON KEY PRIORITIES IN CIRCULAR ECONOMY

| Subprogrammes | Activity name and description |
|---|---|
| A1 Circular complex product design | *A1.1 Analysis of composition and assembly technologies for different existing complex products*<br>*A1.2 Evaluation of secondary resources as raw materials for complex products*<br>*A1.3 Design of complex products for recycling and reuse*<br>*A1.4 Building and testing of pilot plants* |
| A2 Circular business model strategies for complex products | *A2.1 Downgrade materials analysis*<br>*A2.2 Circular business models development*<br>*A2.3 Testing of circular business models* |

### OBJECTIVE B: TO ADDRESS TOXIC/HAZARDOUS SUBSTANCES TO HUMAN AND ENVIRONMENTAL HEALTH IN THE CONTEXT OF CIRCULAR ECONOMY

| Subprogrammes | Activity name and description |
|---|---|
| B1 Circular design and technical development for human and environmental health | *B1.1 Improvement of existing technologies for detecting and separating hazardous materials*<br>*B1.2 Development of new technologies for detecting and separating of hazardous materials*<br>*B1.3 Scaling-up of technologies for detecting and separating hazardous materials*<br>*B1.4 Circular safety design*<br>*B1.5 Traceability systems for communicating chemicals of concern in products*<br>*B1.6 Circular business models for human and environmental health* |

## OBJECTIVE C: TO ELABORATE AND STIMULATE THE ADOPTION OF NEW POLICIES, STANDARD AND PROTOCOLS FOR GOVERNANCE RESOURCE MANAGEMENT SYSTEMS, FOSTERING INTER-STAKEHOLDER COLLABORATION AND INTEGRATED MANAGEMENT IN THE ENTIRE VALUE CHAIN

| Subprogrammes | Activity name and description |
|---|---|
| C1 Traceability and management of raw materials to support governance and standardisation | *C1.1 Flow analysis of critical and non-critical raw materials*<br>*C1.2 European database of raw materials building on suitable IT support*<br>*C1.3 European database of raw materials at regional level* |
| C2 Promoting market viable solutions for circular economy | *C2.1 Materials and sectors analysis*<br>*C2.2 European industrial symbiosis platform (data)*<br>*C2.3 European industrial symbiosis platform (instrument)* |

## RESOURCE EFFICIENCY ON TERRITORY AND SEA

This joint programme focuses on the application of circular economy to the complex relationships between mainland human activities and open waters, chiefly represented by the technosphere environment of harbours. Priority is given to actions that promote transition to the circular economy in the management of small and big ports, fostering sustainable and circular innovations in the major productive sectors occurring in the ports and in the main activities and businesses linked to its economic life.

This joint programme is in line with the emerging Blue Economy principles and the Blue Growth perspective: the main topics addressed include sustainable tourism, integrated and circular waste and water management, climate change impacts including sea level rise and mitigation measures. Based on this, the goal of this joint programme is to enable circular economy transition in ports and marine systems.

### OBJECTIVE A: TO DESIGN AND PROMOTE SUSTAINABLE MARITIME TRANSPORT

| Subprogrammes | Activity name and description |
|---|---|
| A1 Transitioning to a circular and sustainable shipping industry | *A1.1 Development of eco-design approaches for the watercraft production industry*<br>*A1.2 Development of solutions for electric vessels in maritime transport and upscaling of cold ironing at port areas*<br>*A1.3 Development and market upscaling of innovative recyclable composite materials and 3D printing in the watercraft industry* |

### OBJECTIVE B: TO PROMOTE EFFICIENT RESOURCE USE IN PORTS AND COASTAL AREAS WITH A LONG-TERM PERSPECTIVE

| Subprogrammes | Activity name and description |
|---|---|
| B1 Transitioning to integrated resource management approaches working at the territorial level with a holistic and circular perspective | *B1.1 Design and implementation of industrial symbiosis platforms for discards and waste valorisation at ports (in connection with coastal cities)*<br>*B1.2 Calculation models to design (mainly nature-based) climate change adaptation actions in ports and coastal cities*<br>*B1.3 Material flow analysis with a life cycle perspective at ports and coastal cities*<br>*B1.4 Innovation hubs in to foster circular economy in port areas and engagement with coastal cities*<br>*B1.5 Circular and sustainable tourism certification schemes* |
| B2 Transitioning to a sustainable fishing and circular aquaculture sector | *B2.1 Valorisation of fish species with commercialisation and sustainable extraction potential*<br>*B2.2 Valorisation of seafood by-products and promoting industrial symbiosis in the fisheries sector*<br>*B2.3 Implementation of sustainable multitrophic aquaculture processes in the appropriate marine areas* |

# CONTENTS

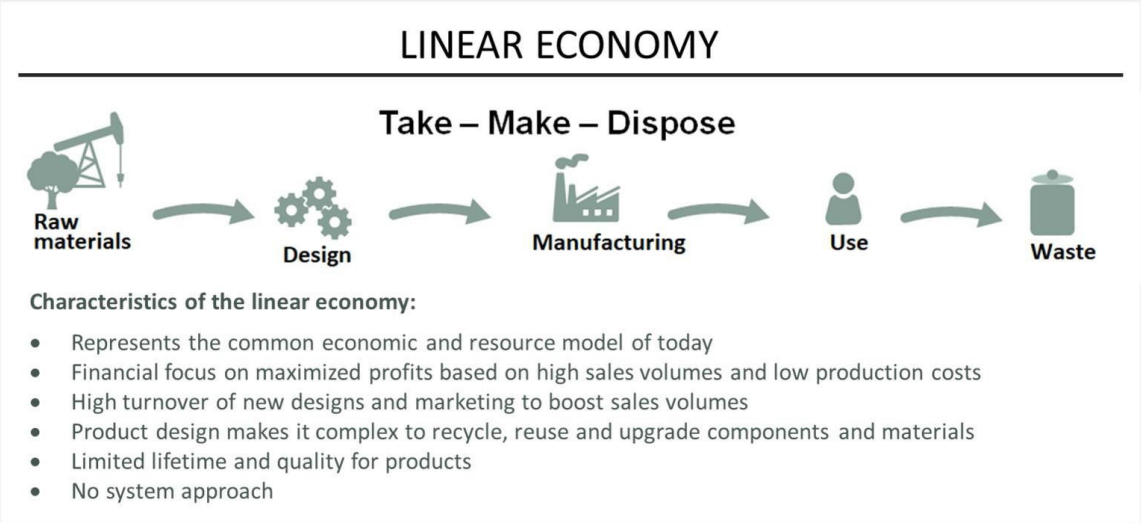
# LIST OF ACRONYMS

| | |
|---|---|
| B2B | Business-to-Business |
| B2C | Business-to-Consumer |
| C&D | Construction and demolition |
| CE | Circular economy |
| CRM | Critical raw materials |
| CSA | Coordination and support action |
| EEE | Electrical and electronic equipment |
| EPR | Extended producer responsibility |
| EU CEAP | European Circular Economy Action Plan |
| GHG | Greenhouse gas |
| IF | Innovation field |
| IF ID | Innovation field ID number |
| IWRM | Integrated water resource management |
| JP | Joint programme |
| ODM | Original design manufacturer |
| OEM | Original equipment manufacturer |
| PO | Programme owner |
| R&I | Research and innovation |
| SME | Small and medium enterprises |
| SRIA | Strategic research and innovation agenda |
| TRLs | Technology readiness levels |

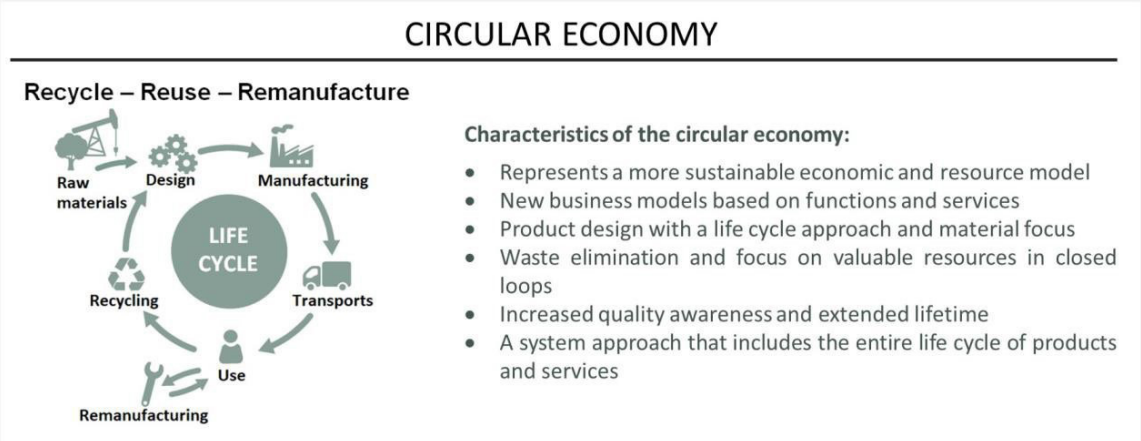
# 1 Introduction

# 1. Introduction

The global economy of today is still based on a linear approach with a focus on exploiting cheap natural resources and managing economies of scale in manufacturing processes. The design of products and services are often built upon limited lifetime expectations and there is great attention on rapidly changing trends and marketing to maximise sales volumes. The traditional linear economy does not focus design and product development on reuse, remanufacturing and material recycling. It also does not consider a systemic approach that incorporates the full value chain perspective. If the global economy remains in this linear form, greenhouse gas emissions and waste generation will continue to grow.




Over time, the understanding and awareness of the unsustainable use of resources in the linear economy has grown. The circular economy approach prioritises sustainable consumption, resource efficiency and retaining the value of materials and products throughout the entire life cycle. This new sustainable way of managing the economy and resources has a significant potential to create positive impact in almost all value chains. It includes product design that is based on life cycle thinking with increased quality awareness and lifetime extension. Circular economy-based business models also place greater emphasis on offering services and functions than material products, as well as inspire society to rethink how individuals interact with services and products to fulfil their various needs. In the circular economy, greenhouse gas emissions decrease and what is conventionally considered as 'waste' is converted into valuable resources.



To tackle the complex challenge of shifting towards a productive circular economy in the EU, the European Green Deal was formed in 2019 as a growth strategy to ensure that economic growth is decoupled from resource use while aiming for zero net emissions of greenhouse gases in 2050. At the same time, the second version of the EU Circular Economy Action Plan (EU CEAP) was released in spring of 2020 to encourage societal transformation to the circular economy, which is also part of the EU Green Deal. Numerous other EU initiatives, including the new Horizon Europe programme, are also increasingly focusing on circular economy-related topics.

As part of the societal transition towards circular economy, adopting a systemic approach to conducting circular economy-related research and innovation is key. However, circular economy is often not directly addressed or defined in funding programmes – with many focusing on specific impacts, for example waste reduction and resource efficiency, which does not consider circular economy in a systemic way. Furthermore, funding often occurs on a highly technical level, targeting specific aspects of the value chain rather than through the lens of systemic change with the involvement of multiple stakeholder groups and citizens - this is slowly shifting, but significant upscaling is needed to increase impact.

Therefore, the CICERONE[2] project is developing the strategic coordination of objectives and programming of regional, national and European funding programmes to streamline circular economy research and innovation. The project is developing a platform for EU programme owners (POs) (i.e. organisations that implement European, national and regional funding programmes on research and innovation) to coordinate and collaborate on priority research and innovation (R&I) actions on circular economy. Part of this process is the development of the circular economy strategic research and innovation agenda (SRIA).

### Why system change?

Switching to a circular economy means changing the entire system we live and operate in – and this will not be achieved through single-point interventions. A systemic approach is needed to create sustained change – looking not only at impact assessments of existing single technologies, business models or policies, but how they interconnect and put pressure on the rest of the system to scale up results. Systemic change means shifting both the function and structure of a system and sustaining change overtime through programmatic intervention.

## What is the Circular Economy SRIA?

This circular economy strategic research and innovation agenda (referred to as “CE SRIA” or simply “SRIA”) is a strategic guidance document that specifically focuses on the topic of circular economy in the European Union. A focus on systemic change and adopting a cross-cutting interdisciplinary approach is at the heart of the CE SRIA. This is reflected by the SRIA’s systemic framework of **eight priority themes** (biomass and biotechnologies, chemicals, construction and demolition, food, plastic, raw materials, waste and water) that build on four societal areas that face sustainability **challenges** (urban areas, industrial systems, value chains and territory and sea) to identify priority areas for circular economy research and innovation to tackle EU region-wide issues and facilitate the transition to a circular economy.[3]

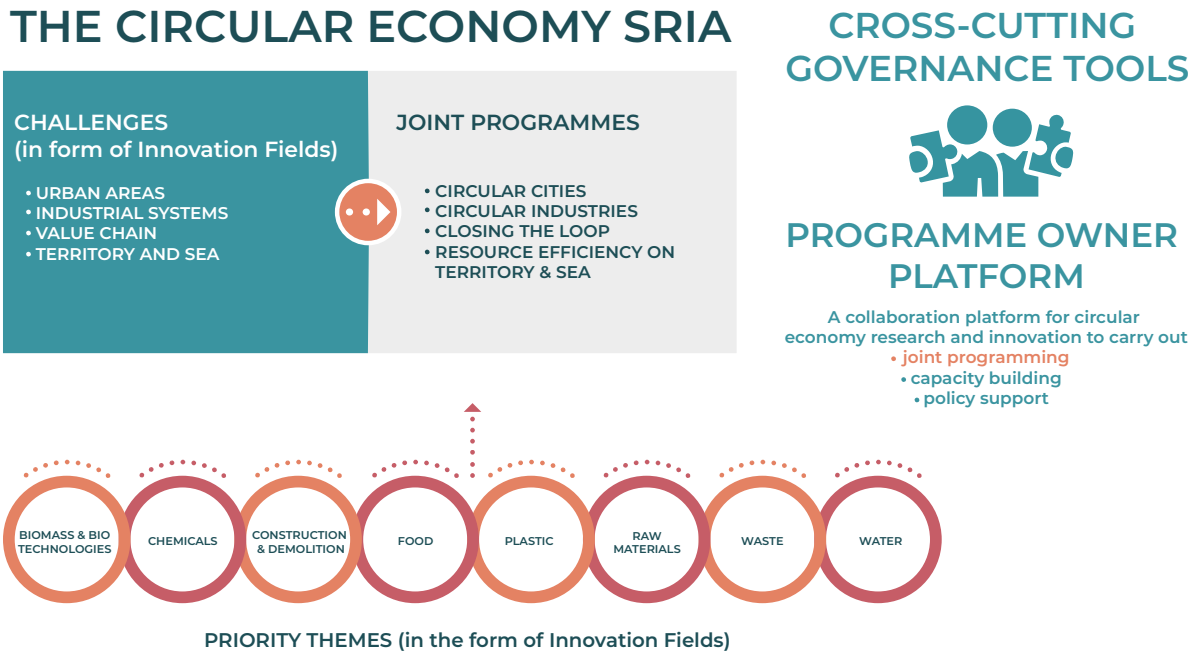
Within each theme and challenge, a set of circular economy **innovation fields** (i.e. broad areas of priority research and innovation) were identified. These are R&I actions that facilitate circular economy transition. These innovation fields were strategically linked to form **four systemic joint programmes** (i.e. structured and strategic research and innovation programmes to ensure an interdisciplinary, cross-sectoral and systemic approach in circular economy R&I). The four joint programmes are: 1) Circular Cities, 2) Circular Industries, 3) Closing the Loop and 4) Resource Efficiency on Territory and Sea. Each joint programme consists of circular economy objectives that the programme aims to achieve.



[2] More information can be found on the CICERONE website: http://cicerone-h2020.eu/

[3] The eight themes were selected by the experts in the CICERONE project based on ongoing European priorities and roadmaps related to green growth, sustainability and circular economy. The four societal challenge areas were developed as an innovative framework for the SRIA to analyse the research and innovation actions needed amongst the eight themes to facilitate circular economy transition.

The conceptual framework of the SRIA is illustrated in the diagram below:




**The systemic approach behind the CE SRIA and the CICERONE project. The CE SRIA feeds into the programme owner (PO) platform to be used by POs to collaborate and implement joint R&I programmes.**

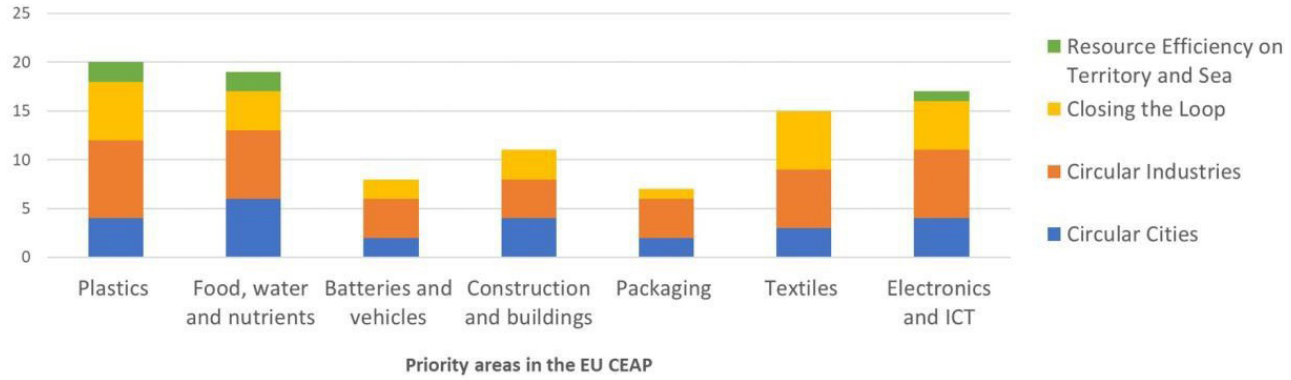
In summary, the following terms are defined and used throughout the SRIA:

- **Innovation fields (IFs)**: areas of research and innovation that are oriented towards functionality and usage value. They are formulated to address clear requirements and encompass technical and scientific solutions. Each priority theme and challenge area consist of a set of relevant innovation fields.
- **Priority themes**: are a core part of the SRIA conceptual framework. They represent material flows (raw, manufactured, primary and secondary materials), within which innovation fields are defined. The eight themes are: biomass and biotechnologies, chemicals, construction and demolition, food, plastic, raw materials, waste and water, and they crosscut the challenge areas. For detailed descriptions, see Section 4.2. Themes.
- **Challenge areas**: are also a core part of the SRIA conceptual framework. They represent various geographical and societal levels on which circular economy systems can be built. Under each challenge area, innovation fields are developed. The four challenges are: urban areas, industrial systems, value chains and territory and sea. They are crosscut by the themes in the overall SRIA framework. For detailed descriptions, see Section 4.1. Societal Challenge Areas.
- **Joint programmes**: structured and strategic research and innovation programmes developed based on innovation fields that were linked together from one challenge and its relevant themes. For example, the Circular Cities joint programme is based on the innovation fields from the Urban Areas challenge area and innovation fields from its relevant priority themes.
- **Objectives**: are found in each joint programme and they set the direction for the development of the joint programmes' actions. They were defined based on the synthesis and analysis of major European strategies and policies on circular economy as well as the input of extensive stakeholder engagement.

Contributing, rather than duplicating, the ambitions and efforts of European strategies and initiatives is a central tenet of the four joint programmes. In this way, the SRIA provides significant added value not only by providing a basis for programme owners to join forces working on circular economy research and innovation, but also in contributing to sustainable socio-economic development in the EU.

## The SRIA's alignment with the EU CEAP

The new EU Circular Economy Action Plan (CEAP) was adopted by the European Commission in spring 2020. With this plan the EU aims to ensure that valuable resources are kept in the EU economy as long as possible and the plan introduces a number of measures that are in line with the European Green Deal. The SRIA contributes to achieving the goals and actions of the CEAP and can be seen in the alignment of the SRIA's joint programmes and subprogrammes to the priority areas of the CEAP. This is summarised in the diagram below.




**Number of SRIA subprogrammes that align with priority areas in the new EU CEAP, categorized by the four joint programmes.**

In general, the SRIA contributes to all priority areas of the CEAP, most strongly in the areas of Plastics, Food, Water and Nutrients, Textiles and Electronics and ICT. The SRIA also contains subprogrammes related to the CEAP's priority areas of Batteries and Vehicles, Construction and Buildings and Packaging. The joint programmes Circular Industries (40 subprogrammes) and Closing the Loop (27) represent the strongest alignment to the CEAP, followed by Circular Cities (25). Resource Efficiency on Territory and Sea has the least alignment with the CEAP however this also represents a difference in the scope of the SRIA beyond the CEAP on targeting issues related to territory and sea. This joint programme is designed to contribute to other relevant strategies, including the Bluemed SRIA[4].

An analysis of how well the SRIA aligns with the EU CEAP, including the alignment of every subprogramme of the SRIA to the CEAP's priority areas can be found Section 6. Alignment of SRIA to Major EU Initiatives.



[4] The Bluemed SRIA can be found here: http://www.bluemed-initiative.eu/wp- content/uploads/2018/12/BLUEMED-SRIA_Update_2018.pdf.

## The SRIA: Developed through collaboration and building on state-of-the-art

The SRIA was developed by mapping and compiling circular economy objectives in the EU by analysing the current state-of-the-art and conducting extensive stakeholder consultation. Analysing the current state-of-the-art involved the mapping of existing circular economy research and innovation programmes in the EU and internationally and interviewing key experts and programme owners involved in such programmes. A case study analysis was also conducted on European joint programmes to identify relevant lessons learned for the SRIA's joint programmes.

The SRIA builds on the current state-of-the-art in circular economy programming as follows:

| Current state of the art[5] and lessons learned | How the SRIA responds |
|---|---|
| **The majority of circular economy-related R&I programmes only addresses circular economy partially by focusing on specific aspects (e.g. resource efficiency, waste as a resource).** | The SRIA addresses circular economy holistically by addressing product lifecycles, whole value chains and the involvement of actors beyond the conventional (e.g. citizen engagement, behavioural sciences and other social aspects). |
| **The largest share of programmes currently being funded are in the areas of technology development, process optimisation and addressing field pilot implementation.** | The SRIA focuses on scaling and market introduction, again by emphasising greater focus on societal linkages, behaviour, the whole product lifecycle (especially design and use phases). It also focuses on achieving higher TRLs on technology development/process optimisation. |
| **The focus of current programmes is predominantly on the waste and biomass material streams, and the most frequently addressed product life cycle phase is the end-of-life phase.** | The SRIA includes both of these material streams (Waste and Biomass) in its scope as well as six others in the priority themes (Chemicals, Construction and Demolition, Food, Plastics, Raw Materials and Water). Furthermore, the SRIA goes beyond the end-of-life phase by focusing on actions in the use phase (e.g. recycling, reusing) and further upstream (e.g. design phase). |
| **Circular economy-oriented product design is an important element in shifting to circular systems.** | The SRIA focuses on creating framework conditions for promoting eco-design. It also addresses eco-innovations in two main fields: 1) hardware (technologies and technical infrastructures) and 2) software (skills, expertise and business models). |
| **There is a lack of long-term up-scaling projects, which is needed to bridge the gap between successful research and actual implementation on an industry level.** | All activities in the SRIA's joint programmes emphasise building off existing state-of-the-art, best practices and knowledge as a basis. Where relevant, many activities are also focused on upscaling in the market and industry levels. |
| **Stronger communication is a key part of joint programming.** | Indeed, the SRIA will be used by programme owners of the platform on which joint programming is a key function. The SRIA includes guidance for PO users for how to use the SRIA to collaborate on joint programming, co- identify new priorities and actions, etc. The platform will also include key functions on the exchange of results and building on best practices. |

The SRIA development process involved extensive stakeholder engagement. This focused primarily on European programme owners at the national, subnational (regional) and local levels, but it also included experts, academia, government/policymakers, SMEs and businesses, industry, NGOs and civil society groups. Multiple consultations and collaborations with stakeholders were conducted to identify the objectives and priority innovation fields, which were used to form the joint programmes of the SRIA. For more details, see ANNEX I: SRIA Methodology

[5] Analysed in the early stages of the CICERONE project which started in November 2018.

## Who is the SRIA created for and how will it be used?

The SRIA takes a highly targeted approach and identifies priority circular economy research and innovation actions based on the input from a broad range of stakeholders and actors across the EU, especially from programme owners as the main target group.

The SRIA is intended for use by members of the joint programming platform (mainly composed of EU programme owners) to co-create, co-fund and work together towards systemic circular economy. Collaboration will be based. on the SRIA's joint programmes which provide strategic guidance for systemic innovation to create holistic, cross-cutting and systemic programmes to create greater impact.

The SRIA is intended to allow for short- and long-term collaborative action – while the joint programmes outline key activities that programme owners can implement together to achieve shared circular economy ambitions, the innovation fields provide strategic direction for the ongoing design of additional circular economy research and innovation programmes as priorities and issues evolve over time. This systemic and long-term focus makes the SRIA complementary to vertical SRIAs and roadmaps on specific topics.

It is important to note that the innovation fields and joint programmes in the SRIA are not intended to be exhaustive but represents priority areas for the EU. In addition, the SRIA itself is intended to be a living document and allow future programme owners to address additional topics from the new EU Circular Economy Action Plan.

## Structure of the SRIA

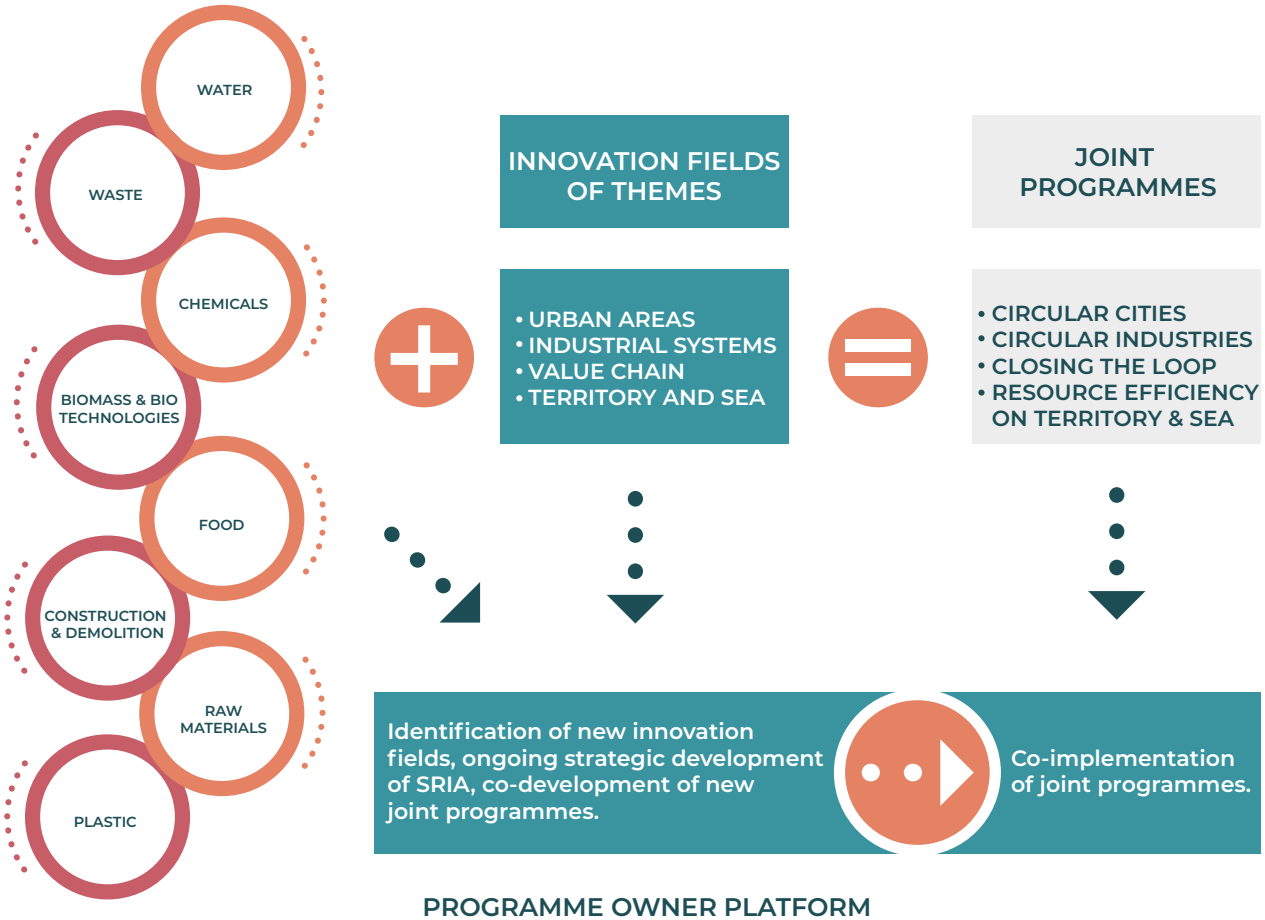
Following this introduction, **Section 2. Overview of the Joint Programmes** provides a list of the subprogrammes under each of the four joint programmes. **Section 3. Detailed Joint Programmes** comprises the bulk of this SRIA and provides the detailed subprogrammes and activities. **Section 4. Research and Innovation Priority Areas (Innovation Fields)** provides the full list of innovation fields for each challenge area and priority theme. **Section 5. Guidance for Programme Owners to Use the SRIA** provides a brief explanation of how POs could use the SRIA to implement joint programming as well as update the SRIA to maintain its relevance to circular economy priorities. **Section 6. Alignment of SRIA to Major EU Initiatives** briefly explains the relevance of the SRIA in contributing to the objectives of the European Green Deal, EU CEAP and Horizon Europe programme. This is followed by **Section 7. Conclusion.**

# 2 Overview of the Joint Programmmes

# 2. Overview of the Joint Programmes

Joint programmes are structured and strategic R&I programmes that define, in further detail, the specific activities, necessary disciplines and actors that should be involved in future R&I actions in the circular economy. There are four joint programmes, each corresponding to a challenge area. They will be used by members of the joint programming platform of programme owners to co-create, co-fund and work together towards systemic circular economy.

It is important to note that the joint programmes are not intended to be exhaustive, given that the selected priorities are based on current circular economy research and innovation in the EU and extensive consultation with EU stakeholders. The joint programmes focus on cross-cutting and transdisciplinary aspects to bring about systemic change, and they also represent examples and templates of how systemic programmes can be built. Indeed, further subprogrammes and activities can be developed out of the priority innovation fields.



**The CE SRIA was developed by identifying innovation fields across eight priority themes and four societal challenge areas, out of which four joint programs were formed. Members of the programme owner platform are expected to use both the joint programmes and innovation fields to collaborate on circular economy programming. These aspects of the SRIA can also be tailored to their needs.**

The following list provides an overview of the joint programmes. Under each joint programme is a list of subprogrammes that further break down joint programming activities by topic.

**A note on TRL levels**: Some of the activities listed in the joint programmes include indication of the approximate current and desired technology readiness levels (TRLs). This was based on the EU's TRL scale but with some adaptation for the purpose of the SRIA. While the EU scale focuses on the maturity level of technologies specifically, the TRLs indicated in the SRIA refer to both *technological and non-technological readiness* to conduct:

- Basic research: TRL 1-2,
- Lab or in-house demonstration: TRL 3-4,
- Field pilot: TRL 5-6,
- Market introduction: TRL 7-8, and
- Scaling: TRL 9.

Since the TRLs of circular economy activities vary widely across the EU, those indicated in the SRIA are approximations only, based on the general extent to which the listed joint programme activities already exist across the EU, their potential to develop and scale, and with a timeline of up to the year 2030 for the desired TRL to be reached.

## 3.1 CIRCULAR CITIES

**Objective A: To enable urban circularity and increasing citizen engagement in circular solutions**

Subprogramme A1: Infrastructure to enable circular material and product flows

Subprogramme A2: Citizen participation in circular material and product flows

Subprogramme A3: Enhancing material efficiency and circular flows in the food and food packaging sector

**Objective B: To enhance circular economy and natural resource management in urban areas**

Subprogramme B1: Circular economy considerations of water and soil in food systems

Subprogramme B2: Circular economy in land and soil resources in construction and urban planning

Subprogramme B3: Circular economy considerations in water supply and treatment systems

Subprogramme B4: Shifting towards circular water systems in buildings

## 3.2 CIRCULAR INDUSTRIES

**Objective A: To develop new technologies, processes, quality standards and analytic methods for new materials production and for resource and waste characterisation**

Subprogramme A1: Developing new technologies for new materials production

Subprogramme A2: Developing quality standards and analytic methods for materials production and characterisation

Subprogramme A3: Developing new technologies for resource and waste characterisation

**Objective B: To enable industrial symbiosis networks and foster digitalisation to master the complexity of products, processes and systems**

Subprogramme B1: Smart Factories - Building SME partnerships, "alliances of interests" and industrial symbiosis networks

**Objective C: To raise awareness of industrial ecology by promoting new/better design and use of products and better re-use of materials already in circulation**

Subprogramme C1: Promoting eco-design and eco-processes

Subprogramme C2: Promoting re-use, repair and remanufacturing

**Objective D: To reduce the carbon emissions of companies**

Subprogramme D1: Greenhouse gas accounting and management system (individual company*)

Subprogramme D2: Promoting secondary raw materials market and industry

Subprogramme D3: Reducing the carbon and GHG emissions in industrial systems

## 3.3 CLOSING THE LOOP

**Objective A: To ensure that the manufacturing partnerships in Horizon Europe focus on key priorities in circular economy**

Subprogramme A1: Circular complex product design

Subprogramme A2: Circular business model strategies for complex products

**Objective B: To address toxic / hazardous substances to human and environmental health in the context of circular economy**

Subprogramme B1: Circular design and technical development for human and environmental health

**Objective C: To elaborate and stimulate the adoption of new policies, standard and protocols for governance resource management systems, fostering inter-stakeholder collaboration and integrated management in the entire value chain**

Subprogramme C1: Traceability and management of raw materials to support governance and standardisation

Subprogramme C2: Promoting market viable solutions for circular economy

## 3.4 RESOURCE EFFICIENCY ON TERITORY AND SEA

**Objective A: To design and promote sustainable maritime transport**

Subprogramme A1: Transitioning to a circular and sustainable shipping industry

**Objective B: To promote efficient resource use in ports and coastal areas with a long-term perspective**

Subprogramme B1: Transitioning to integrated resource management approaches working at the territorial level with a holistic and circular perspective

Subprogramme B2: Transitioning to a sustainable fishing and circular aquaculture sector

# 3 Detailed Joint Programmmes

# 3. Detailed Joint Programmes

## 3.1 CIRCULAR CITIES

Cities are important engines for the transition towards the circular economy. Today, 75% of the population in Europe is living in urban areas, and this is still growing. Cities are where the majority of economic activities, consumption, emissions and waste production take place. At the same time, European cities hold great knowledge and significant human, financial, technological and infrastructural resources. These assets empower cities to lead the transition towards the circular economy and unlock related economic, environmental, and social benefits.

The development of urban sustainability has been the basis of many European initiatives related to circular economy. The Ellen MacArthur Foundation described a vision of circular economy in cities as one where waste and pollution is designed out of cities, products and materials are kept in use to maintain their value, and natural systems are regenerated in and around cities.[6] The new EU Circular Economy Action Plan identifies the importance of making circularity work for people, regions and cities. The European Green Deal also identified the need to reduce urban air pollution especially from transport, the importance of citizen dialogues and inclusion of citizens in sustainable urban development, and the role of cities to contribute to climate change mitigation. The Joint Programming Initiative (JPI) Urban Europe programme identifies four sustainable development areas for cities: 1) digital transition in urban governance, 2) from resilience to urban robustness, 3) sustainable land- use and urban infrastructure, and 3) inclusive public spaces for urban liveability[7].

Achieving the vision of a circular society requires rethinking how we use different products, services and materials and how to find new ways of creating value while addressing the urban challenges of today.[8] The Circular Cities subprogramme of this SRIA complements the above strategies and initiatives to create systemic change from the circular economy perspective, especially in the areas of creating closer engagement and involvement of urban citizens and enhancing the circularity of resources, materials and products.

Based on the above, the goal of this joint programme is *to facilitate and promote the transition to circular economy in urban areas in line with existing sustainable urban development initiatives*. Specifically, the objectives the joint programme are:

1. To enable urban circularity and increasing citizen engagement in circular solutions, and
2. To enhance circular economy and natural resource management in urban areas.

Given the many possible areas of work in circular economy and cities, the activities presented in this joint programme represent a starting point for programme owners to collaborate on circular economy research and innovation across the EU, and they also reflect the priorities identified by key stakeholders on cities in the development of this SRIA. Further activities can and should be developed jointly by programme owners as priorities and issues change in European cities.

Nonetheless, the activities outlined in this subprogramme are expected to deliver the following impacts:

- Reduced use of resources and related environmental impacts through innovations enabling better infrastructure and the engagement of citizens;
- Increased material efficiency in the food waste sector and decreased packaging per unit weight of products;
- Improved soil quality and increased resource efficiency for water, soil and nutrients in urban areas; and
- Improved land and soil management through better construction practices and urban planning.

[6] See https://www.ellenmacarthurfoundation.org/assets/downloads/CE-in-Cities-Project-Guide_Mar19.pdf
[7] See https://jpi-urbaneurope.eu/about/sria/sria-2-0/
[8] URL: https://www.circularcityfundingguide.eu/circular-cities/

## Objective A: To enable urban circularity and increasing citizen engagement in circular solutions

### *Subprogramme A1: Infrastructure to enable circular material and product flows*

**Rationale for the subprogramme**

This subprogramme focuses on innovations in infrastructure and service development to complement and facilitate increased citizen participation in circular material and product flows. It requires making collection system convenient, user-friendly and informative (but not to produce information overload). The subprogramme focuses on both digital (e.g. sensors, apps) and non-digital innovations to incentivise citizen participation and boost acceptance. Special focus is required for the planning and design of construction and demolition (C&D) materials in order to increase reuse/recycling. In all activities, the inclusion of a territorial Responsible Research and Innovation (RRI) approach is important during the analysis of social and behavioural barriers for citizens and for a systematic transition to CE.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **A1.1 Technical development and digitalisation of waste systems**<br>This activity involves:<br>▪ Mapping and creating inventories of existing technologies and initiatives for waste management (e.g. collection systems, digital tools and systems).<br>▪ Scaling up, expanding industry involvement, exploring and piloting innovative policy programmes and instruments, and business models.<br>▪ Developing and implementing measures to engage and incentivise citizens and building consumer acceptance, to facilitate improvements in the waste management system<br>▪ Developing a market for the solutions found.<br>▪ Conducting research to develop novel technologies and processes, including biomimicry.<br>▪ Implementing demonstration projects.<br>▪ Conducting consumer (user) tests.<br>TRL: Lab or in-house demonstration (4) --> TRL: Market introduction (8) - Scaling (9) | ▪ Digitalisation experts (sensors, AI, etc.)<br>▪ Service design<br>▪ Systems design<br>▪ Municipalities<br>▪ Private collector and waste management companies |
| **A1.2 Improved collection systems for reuse, remanufacturing and sharing**<br>This activity involves:<br>▪ Investigating various collection points in EU cities to maximise reuse flows.<br>▪ Scaling up collection for reuse and remanufacturing.<br>▪ Developing and implementing policy innovations to modify collection systems (from recycling to reuse).<br>▪ Optimising systems, with a systemic perspective to integrate considerations of culture, infrastructure, existing second-hand sectors, web platforms, social dimensions and preparation for reuse, sharing and remanufacturing (e.g. repair networks).<br>▪ Developing and implementing measures to engage and incentivise citizens and build consumer acceptance<br>▪ Prioritising electrical and electronic equipment, textile and bulky waste streams (e.g. construction and demolition waste), which may be good starting points. | ▪ Municipalities<br>▪ Private actors<br>▪ Retailers (shopping centres)<br>▪ Repair actors<br>▪ Policy makers<br>▪ City planners |

| | |
|---|---|
| ▪ Research on how to increase the efficiency of waste collection from end-of life electrical and electronic equipment (EEE) and sustainable future technologies (wind miles, solar panels etc.) that contain critical raw materials (CRMs) in order to facilitate the economy of scale for the recycling of CRMs from waste at regional or global level.<br><br>TRL: Lab of in-house demonstration (4) --> TRL: Market introduction (8) - Scaling (9) | |
| **A1.3 Planning and design for reuse and recycling**<br><br>This activity involves:<br><br>▪ Planning of construction and demolition (C&D) waste collection systems to improve reuse and recycling.<br>▪ Designing C&D materials and buildings for reuse and recycling (modular design).<br>▪ Leveraging on the "Renovation Wave" as an opportunity to upscale circularity in the construction and renovation sector.<br>▪ Developing and implementing measures to engage and incentivise citizens and build consumer acceptance.<br>▪ Developing product passports and smart identification systems (and/or building on existing and state-of-the-art systems).<br>▪ Developing or upscaling the use of material banks for used materials.<br>▪ Internalising external impacts in material and service pricing.<br>▪ Involving citizen engagement with waste management.<br><br>TRL: Lab or in-house demonstration (4) --> TRL: Market introduction (7- 8) | ▪ Municipalities<br>▪ Private actors<br>▪ Citizens<br>▪ Designers (including interior designers)<br>▪ Developers<br>▪ Construction and renovation companies<br>▪ Architects<br>▪ Consumers |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| A1.1 Technical development and digitalisation of waste systems | A1.2 Improved collection systems for reuse, remanufacturing and sharing<br><br>A1.3 Planning and design for reuse and recycling |

### *Subprogramme A2: Citizen participation in circular material and product flows*

**Rationale for the subprogramme**

Designing waste out of cities and maintaining the use and value of materials in cities are central tenants of circular economy in urban areas. It is also widely covered in the EU CE Action Plan with directives, legislation proposals and other tools to turn waste into valuable resources.

While measures to improve waste management systems have involved both infrastructural development and awareness raising/social campaigns, in general more focus has been placed on the infrastructural and technological aspect. A systemic transition to circular economy is not possible without the extensive engagement of citizens, especially in cities and urban areas. The EU CE Action Plan also identifies citizen dialogues as a significant aspect in circular economy transition.

This subprogramme complements Subprogramme 1.1 above to couple citizen participation actions with infrastructure development in enhance material and product circularity. This subprogramme focuses on citizen and user engagement in the circular economy, especially in the areas of enhancing the circularity and improving the efficiency of material and product flows. It aims both to enhance the use and expand the 'body of knowledge' of scientific insights on behaviour change and providing alternative behaviour patterns. The programme is also intended to complement efforts to tackle ongoing policy issues related to the sharing economy, such as thresholds for regulation, consumer protection, IPR, competition, labour market and taxation, where such political and economic aspects are not directly addressed in this SRIA.

To fulfil the objective in this subprogramme, there is a need to focus on infrastructure for waste collection to improve its sorting, identify valuable waste materials and improved information and education. It also requires new incentives for citizens to support waste sorting both financially and practically. Product design improvements that facilitate a more efficient waste separation and sorting is also required.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **A2.1 Analysis of the current situation on inefficiencies and opportunities for waste collection and recycling**<br>This activity involves:<br>▪ Compiling existing projects and studies (background study).<br>▪ Developing a framework for identifying these key gaps/opportunity areas, taking into the differences in local contexts.<br>▪ Analysing and identifying major gaps in separation and collection of waste streams and materials where citizen engagement is a key lever.<br>▪ Analysing the sources of issues and how these gaps and barriers can be overcome with citizen participation.<br>▪ Analysing conflicts and matching between existing waste management infrastructure and the bio-based packaging industry (including the certification body).<br>Desired TRL: N/A | ▪ Academics/ researchers<br>▪ Input from municipal policymakers, citizens, waste management, producers, retailers<br>▪ Municipal actors from cities that have climate-neutral goals or similar climate ambitions |
| **A2.2 Coordination and implementation of citizen engagement in waste sorting and collection for target waste streams**<br>This activity involves:<br>▪ Using the framework from activity 1 above to identify cases in EU cities where systems for increased citizen engagement in waste sorting and separation can be implemented. | ▪ Municipal policymakers<br>▪ Waste management actors and recyclers<br>▪ Citizens and households |

| | |
|---|---|
| ▪ Including tools, technologies and infrastructure for waste sorting and collection in Subprogramme 1.1. It should also include information and education programmes in parallel.<br>▪ Involving citizen engagement with waste management.<br>▪ Focusing on solutions that make business and financial sense and align with the interests of citizens and households.<br>Desired TRL: N/A | ▪ Producers and retailers |
| **A2.3 Analysis of social and behavioural barriers for consumers and citizens for systemic transition to circular economy**<br>This activity involves:<br>▪ Focusing on geographic and sectoral areas where insight on social and behavioural factors on citizens in the circular economy is currently missing.<br>▪ Compiling existing analyses on the barriers to transition to circular economy and circular economy initiatives specifically from the consumer and citizen perspective.<br>▪ Accounting for differences in countries or regions and culture and where concrete barriers are (e.g. low awareness, lack of infrastructure and systems, financial barriers).<br>▪ Designing programmes to capture genuine citizen engagement and spark change to sensitise them on the issue. This may include policy innovations<br>▪ Analysing motivations for stakeholders (customers, private sector, public sector).<br>▪ Analysing the social and health benefits of urban circular models specific to the target cities or geographic area (e.g. community building, social cohesion from repair cafes and others).<br>▪ Researching consumer behaviour and preferences related to sharing (rental, take back) models specific to the target cities or geographic areas.<br>▪ Researching behavioural change in connection to decreased consumption, increased recycling & reuse.<br>▪ Research on how to measure the avoidance of resource use including evaluation of potential rebound effects.<br>Desired TRL: N/A | ▪ Behavioural economists<br>▪ Social scientists<br>▪ Civil society organisations<br>▪ Consumers<br>▪ Citizens<br>▪ Psychologists and psychology experts (in relation to health benefits) |
| **A2.4 Coordination to scale up existing repair and reuse stations (physical and digital)**<br>This activity involves:<br>▪ Mapping (or literature review) of existing repair and reuse programmes at city level[9].<br>▪ Investigating most common reused products.<br>▪ Assessing consumer demand, barriers to uptake/upscale repair and reuse actions. | ▪ Operators of existing product repair and reuse programmes/ stations<br>▪ Experts in product design, service design, material experts, digital platform/app developers, behavioural/social |

[9] *Examples of studies include: Grassroots Innovation and the Circular Economy - A Global Survey of Repair Cafés and Hackerspaces (Keiller and Charterm, 2014), Improving product reparability: Policy options at EU level (2015), Material and Waste Management in a Circular City (Fischer, Menger, Bastein and Wilts, 2017) and Machbarkeitsstudie zum Aufbau einer Qualitätsgemeinschaft Reparatur in Berlin (Henseling, Degel and Oertel, 2018)*

| | |
|---|---|
| ▪ Assessing existing business models and developing new business models and solutions to overcome barriers.<br>▪ Introducing or scaling up urban circular economy production systems, including digital applications (e.g. to broker the exchange of services, goods or materials), maker-labs (e.g. to promote local production, local repair and manufacturing).<br>▪ Implementing upscaling programmes.<br>▪ Involving the participation of producers for consideration in future product design.<br>▪ Developing, improving and upscaling certification or standard systems on the quality and performance of used products or parts.<br>TRL: Field pilot (6) --> TRL: Market introduction (8) | scientists, business experts and economists, communications/public relations experts<br>▪ Municipal actors/ authorities (e.g. cooperation between waste management administration and procurement department)<br>▪ Consumers and citizens (city level)<br>▪ Producers (brands and corporations of the products involved)<br>▪ EU partnerships and research and development networks on standards and common framework conditions (as relevant)<br>▪ National level organisations responsible for standardisation and certification (as relevant) |
| **A2.5 Product design that facilitates use-life extension and consumer involvement**<br>This activity involves:<br>▪ Introducing or piloting new product lines or integrating use-life extension properties to existing product lines in partnership with producers.<br>▪ Scaling up the integration of circular business models in companies and estimating the volume of reused products to enable business model development and definition of input materials in product design.<br>▪ Considering the optimisation of the value per weight of raw material use by designing products that facilitate product servitisation, sharing and extension of operational lifetime.<br>▪ Considering design aspects on chemicals traceability and providing information on chemicals of concern.<br>TRL: Lab of in-house demonstration (4) --> TRL: Market introduction (7) (on average, since EU cities and sectors differ widely on this) | ▪ Experts in product design, service design, material experts, environmental chemistry<br>▪ Operators of product repair and reuse stations at municipal level<br>▪ Producers (brands and companies of targeted products<br>▪ Consumers |

| | |
|---|---|
| **A2.6 Development of innovative inclusive governance approaches on citizen participation**<br><br>This activity involves:<br>▪ Developing governance innovations that is inclusive and has a strong focus on the involvement of citizens. This can be realised through participative mechanisms such as urban living lab and in central public spaces, adopting a citizen science approach.<br>▪ Co-designing and implementing projects with a strong support from the national and local government and the active participation from citizens.<br><br>TRL: Field pilot (5) --> TRL: Market introduction (8) (with geographical differences) | ▪ Local government<br>▪ Social scientists<br>▪ Political scientists<br>▪ Civil society organisations<br>▪ Citizens |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| A2.1 Analysis of the current situation on inefficiencies and opportunities for waste collection and recycling<br><br>A2.2 Coordination and implementation of citizen engagement in waste sorting and collection for target waste streams<br><br>A2.3 Analysis of social and behavioural barriers for consumers and citizens for systemic transition to circular economy | A2.4 Coordination to scale up existing repair and reuse stations (physical and digital) |

### *Subprogramme A3: Enhancing material efficiency and circular flows in the food and food packaging sector*

**Rationale for the subprogramme**

Food and food packaging waste and inefficiency have been highlighted as some of the biggest challenges that need to be addressed in circular economy, especially in the EU Circular Economy Action Plan. Based on the Action Plan and the EU Plastics Strategy, the EU aims to make all packaging recyclable or reusable by 2030.

Citizens, as consumers of food and food products, play a significant role in this shift. This involves changing their attitude and behaviour in how food is consumed and managed, also including how food is packaged and stored. At the same time, infrastructure and services need to be established to complement and respond to citizen behaviour shifts. There is a need for ambitious circular economy actions to reduce both the scale and volume of materials within circular flow systems while fulfilling citizen needs (for food and nutrition) and minimising material use and waste. This means reducing the area in which the circular process is achieved, e.g. community composting to reduce circular flow of food waste so that wastes are composted in the same area in which they are produced; or decreasing the amount of packaging used per unit weight of product to minimise material use and wastes. This subprogramme focuses on coupling the citizen engagement/behavioural aspects with infrastructural development to enhance material efficiency and circularity in food and food packaging.

This subprogramme focus on increasing material efficiency and circular flows in the food and food packaging sectors and at the same time considers the importance of packaging to reduce levels of food waste. This requires measures such as involvement of reverse logistics, analysis of trade-off from reducing volume of both food and packaging flows (e.g. reducing amount of packaging means less volume/need for recycling sector), consideration of marketing aspects and consumer psychology (e.g. perceptions of value based on amount of packaging versus amount of usable product). It is also important to fulfil citizen needs for food and nutrition with minimal material use. The subprogramme focuses on leverage on environmental motivations of younger and future generations to provide services that reduce or remove packaging. Shifting to more local and seasonal food especially switching to vegetarian and vegan diets is important for the climate change mitigation perspective. The subprogramme considers the need of integrated chemicals management, which involves ensuring that products and packaging are free of chemicals of concern and hazardous chemicals in the first place, or at least knowing chemical composition of products (i.e. information sharing aspect).

Citizens specifically need businesses and products that reduce packaging, information and awareness raising measures for these products and services as well as information on chemicals in products to facilitate consumer decisions.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **A3.1 Review of packaging-free and reduced packaging businesses and good practices/cases**<br>This activity involves:<br>▪ Conducting an inventory of innovative packaging-free and/or reduced packaging products and services. This can include both desk research and interviews with practitioners of the cases studied – analysis of their success factors, failures and lessons learned in their contexts.<br>▪ Analysing potential adverse effects of reduced packaging (e.g. food loss due to shorter shelf-lives or perverse behaviour such as unpackaging food in the stockroom of the store (thus shifting the problem of packaging from the household to the store) in relation to net benefits.<br>▪ Analysing gaps and barriers for upscaling or expansion of these cases in the EU, especially from the view of consumer and citizen participation. | ▪ Producers and brands<br>▪ Supply chain actors<br>▪ Product and packaging designers<br>▪ Chemists and environmental scientists<br>▪ Communications experts<br>▪ Marketing experts<br>▪ Policymakers |

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| ▪ Analysing how to develop sustainable business models.<br>▪ Analysing consumer/citizen needs to fulfil food and nutrition function and what is necessary – balancing needs vs. wants.<br>▪ Analysing safe packaging design: chemicals-of-concern in products and whether/how such information is communicated to consumers. Focus should be placed on plastic-related materials.<br>▪ Developing recommendations for overcoming these gaps and barriers especially from a citizen engagement, participatory and social perspective.<br>▪ Considering and encouraging risk-assessment and risk- management based practices in order to reduce health risks, introducing strict harm-reduction and safety measures.<br>Desired TRL: N/A | ▪ Citizens/consumers<br>▪ Retailers |
| **A3.2 Analysis of new future-proof food and nutrition concepts from the resource efficiency and food security perspective**<br>This activity involves:<br>▪ Conducting inventory of new concepts, technologies, behaviours and an analysis of impacts on circular economy based a food products related case (e.g. products form vertical city farming, insects-based foodstuffs, fermentation technologies).<br>▪ Evaluating new "future-proof" concepts in terms of their impacts on/contribution to the concept of CE.<br>▪ Analysing the potential for market uptake and consumer acceptance and behavioural adaptation.<br>Desired TRL: N/A | ▪ Producers and farmers<br>▪ Entrepreneurs and start-ups<br>▪ Citizen/consumers<br>▪ Food hygienists<br>▪ Marketing experts<br>▪ Nutritionists<br>▪ Policymakers<br>▪ Municipalities<br>▪ Food retailers |
| **A3.3 Upscaling re-commercialisation and valorisation of commercial and agricultural food waste**<br>This activity involves:<br>▪ Conducting an inventory of current SMEs and initiatives to valorise close-to-expiry food.<br>▪ Developing or upscaling technological innovations and regulatory changes to re-commercialise expired retail and commercial food, including related aspects such as transport logistics. This can also include changes to food waste categorisation to decriminalise use of usable but expired food.<br>▪ For food and organic waste from the agricultural sector, promoting and upscaling the use of by-products (e.g. crop waste in animal feed, manure in fertiliser and other nutrient recovery from organic wastes). Traceability should be integrated to safeguard human, animal and environmental health, and ensure social acceptance<br>Desired TRL: N/A | ▪ Food producers and farmers<br>▪ Retailers and brands<br>▪ Policymakers and ministry representatives<br>▪ Citizens/consumers<br>▪ Communications experts<br>▪ Supply chain actors<br>▪ Start-ups |

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| **A3.4 Coordination to scale up recycled/reusable food packaging and packaging-free/reduced packaging (where appropriate)**<br><br>This activity involves:<br><br>▪ Building on existing research and efforts towards 100% recyclable or reusable packaging (or as much as possible in compliance with safety and other considerations). This includes building on basic research and technological development as well as market introduction and scaling.<br><br>▪ Where appropriate, leveraging on the outcomes of above activities to scale up packaging-free/reduced packaging products and services in EU cities. Strong consideration needs to be made in ensuring net positive impacts, and avoiding negative side effects such as potential food loss and resulting net increase in carbon footprint<br><br>▪ Including interventions to build lasting business models<br><br>▪ Scaling up these activities and considering issues on hazardous chemicals or chemicals-of-concern, including the latest research on unregulated chemicals risks<br><br>▪ Conducting innovative education and communication campaigns to shift consumer and citizen behaviour to "rethink" their needs and how it reflects in their purchasing decisions<br><br>Desired TRL: Market introduction (7-8) | ▪ Producers and brands<br><br>▪ Supply chain actors<br><br>▪ Product and packaging designers<br><br>▪ Chemists and environmental scientists<br><br>▪ Communications and science popularisation experts<br><br>▪ Marketing experts<br><br>▪ Policymakers<br><br>▪ Citizens/consumers<br><br>▪ Retailers<br><br>▪ Food hygienists |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| A3.1 Review of packaging-free and reduced packaging businesses and good practices/cases | A3.3 Upscaling re-commercialisation and valorisation of commercial and agricultural food waste |
| A3.2 Analysis of new future-proof food and nutrition concepts from the resource efficiency and food security perspective | A3.4 Coordination to scale up recycled/reusable food packaging and packaging-free/reduced packaging (where appropriate) |

## Objective B: To enhance circular economy and natural resource management in urban areas

### *Subprogramme B1: Circular economy considerations of water and soil in food systems*

**Rationale for the subprogramme**

Soil health, food and bioeconomy are among the priorities of the new Horizon Europe programme. Indeed, waste use efficiency and sustainable soil management are two of the biggest problems in sustainable food production. In a circular economy, these two aspects must be managed alongside food waste management – another key priority in EU circular economy-related initiatives. This subprogramme is intended to address such issues to close the loops for nutrients and water in food systems.

This subprogramme focuses on closing material loops so that nutrients, water and soil should be managed to shift food systems towards circular economy. It requires that nutrients are cycled back in the areas where the food is produced as well as food production practices include the optimisation of water use.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **B1.1 Scaling up organic waste collection, diversion from landfills and reuse for energy and food production (soil nutrient cycling and replenishment)**<br>This activity involves:<br>▪ Mapping and conducting inventories of existing technologies and initiatives.<br>▪ Scaling up, expanding industry involvement, exploring and piloting policy programmes, instruments and business models.<br>▪ Developing the market for fertiliser from recycled sources.<br>▪ Collaborating between cities and municipal policymakers and land-use planners.<br>TRL: Field pilot (5) - (6) --> TRL: Scaling (9) | ▪ Civil and infrastructural engineers<br>▪ Municipal policymakers and land-use planners<br>▪ Agricultural sector (e.g. farmers, associations)<br>▪ Local communities and households |
| **B1.2 Scaling up wastewater recovery and recycling for irrigation and food production**<br>This activity involves:<br>▪ Mapping and conducting inventories of existing technologies and initiatives.<br>▪ Scaling up, expanding industry involvement, exploring and piloting policy programmes and instruments, business models.<br>▪ Developing urban-rural/agricultural infrastructure and market for wastewater reuse.<br>▪ Conducting research to increase the effectiveness of decentralised wastewater treatment technologies.<br>▪ Creating and promoting collaboration between cities/municipal policymakers and land-use planners.<br>TRL: Field pilot (5) - (6) --> TRL: Scaling (9) | ▪ Civil and infrastructural engineers<br>▪ Municipal policymakers and land-use planners<br>▪ Agricultural sector (e.g. farmers, associations)<br>▪ Local communities and households |

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| **B1.3 Mapping of food systems in the EU to identify opportunities for circularity**<br>This activity involves:<br>▪ Mapping and conducting scenario modelling of food systems with the aim to understand food production, supply chain, consumption and transport systems considering urban-rural interactions.<br>▪ Considering issues on food quality and safety, energy balance, economic sustainability, stakeholder attitudes and resource efficiency.<br>▪ Identifying where raw materials are extracted, where biomass is grown and where it is transported/disposed – to identify where nutrient and water loops should be closed.<br>TRL: Basic research (1) --> TRL: Basic research (2) | ▪ Lifecycle analysis (LCA) experts<br>▪ Systems analysts<br>▪ Food and agriculture value chain actors<br>▪ Consumers<br>▪ Brands and corporations, businesses |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| B1.1 Scaling up organic waste collection, diversion from landfills and reuse for energy and food production (soil nutrient cycling and replenishment)<br>B1.2 Scaling up wastewater recovery and recycling for irrigation and food production | B1.3 Mapping of food systems in the EU to identify opportunities for circularity |

## *Subprogramme B2: Circular economy in land and soil resources in construction and urban planning*

**Rationale for the subprogramme**

In the circular economy, the role that land and soil management plays in construction and urban planning is on optimising the use of space for human use and food production. It is also focused on conserving land and soil to make use of existing resources and the avoid extraction of virgin resources. The EU Green Deal identifies the "Renovation Wave" as an opportunity to significantly integrate sustainability measures in buildings and construction. The inclusion of citizens in public spaces is also important and ought to be considered in urban planning.

This subprogramme focuses primarily on land and soil resources when developing circular economy measures in construction and urban planning. This requires measures such as optimising land use to limit greenfield development, optimising the use of living space and land for food production, maximising the efficiency of natural resource use and avoiding virgin resource extraction, valuing cultural and historical heritage and integrating climate change mitigation and adaptation through urban planning innovations.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **B2.1. Overcoming barriers to scale up brownfield development and land reuse**<br>This activity involves:<br>▪ Developing and introducing measures to comprehensively map and plan at the early stages of inventorying brownfield sites, conducting feasibility studies, involving local communities and incorporating all stakeholders and disciplines.<br>▪ Developing financial instruments and investments to make brownfield development more cost-effective. This includes land remediation techniques, feasibility study methods and technologies.<br>▪ Developing policy innovations to enable and incentivise greater brownfield development projects. This includes legislation changes, tax incentives and investments.<br>Desired TRL: Scaling (9) | ▪ Urban planners, land-use policymakers<br>▪ Environmental scientists and ecotoxicologists<br>▪ Environmental chemists<br>▪ Stakeholder and community engagement experts<br>▪ Real estate market experts, economists<br>▪ Construction companies and developers |
| **B2.2 Scaling up of reusing private and public spaces**<br>This activity involves:<br>▪ Investigating policy innovations to enable greater reuse of spaces, beyond residential space into commercial and public spaces.<br>▪ Conducting inventories of existing studies on behavioural barriers and opportunities to space sharing and leveraging on findings and recommended solutions to devise next steps/interventions.<br>▪ Enhancing the engagement between space users, real estate developers and agents, building owners and property managers to develop sustainable business models, with the aim to scale up.<br>▪ Investigating sustainable and circular pop-up building installations for crisis management<br>TRL: Lab or in-house demonstration (3) - (4) --> TRL: Market introduction (7)/(8) - Scaling (9) | ▪ Urban planners and land-use policymakers<br>▪ Real estate market experts, economists<br>▪ Building and property owners<br>▪ Citizens and users<br>▪ Behavioural and social scientists<br>▪ Architects |

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| **B2.3 Circular economy in urban transport systems**<br><br>This activity involves:<br>▪ Urban planning strategies and measures that enable effective mobility planning and even reduce the need for transport (e.g. sustainable compact city development).<br>▪ Developing and upscaling solutions that minimise and optimise trip lengths/ duration and energy use.<br>▪ Promoting zero-emissions transport and mobility solutions, low lifecycle impact vehicles and transport systems.<br>▪ Prioritising and promoting material circularity in transport systems and equipment.<br>▪ Adopting digital and data solutions for mobility optimisation.<br>▪ Developing and upscaling innovative freight strategies to implement efficient reverse logistics and resource flows.<br>▪ Upscaling innovations on shared mobility to optimise freight and human transport.<br>▪ Integrating circularity metrics (e.g. efficiencies in mobility optimisation, material use, energy consumption, GHG emissions) in public and municipal procurement.<br><br>TRL: Basic research (1) - (2) --> TRL: Market introduction (7) - (8) | ▪ Urban planners<br>▪ Municipalities<br>▪ Product and system designers<br>▪ Citizens and users<br>▪ Construction and engineering companies |
| **B2.4 Urban farming to provide ecosystem services, food, water storage and cooling, climate mitigation/adaptation**<br><br>This activity involves:<br>▪ Implementing urban farming systems (pilot and demo).<br>▪ Scaling up urban farming systems.<br>▪ Developing and testing policy innovations to enable the systemic upscaling of urban farming.<br>▪ Investigating and testing measures to boost social acceptance and citizen engagement, analysis of behavioural barriers (links with Objective 1).<br>▪ Research and implementation of integrative urban planning with nutrient exchange with the green belt around the city and its connection to commodity production.<br><br>TRL: Field pilot (5) - (6) --> TRL: Market introduction (7)/(8) - Scaling (9) | ▪ Farmers and agricultural experts<br>▪ Building managers<br>▪ Architects<br>▪ Building residents/ users<br>▪ Consumers<br>▪ Urban policymakers |

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| **B2.5 Historical cultural heritage and natural capital enhancement**<br>This activity involves:<br>▪ Developing and implementing policy innovations, tools and technologies to protect and valorise cultural heritage.<br>▪ Developing an integrated accounting methodology to assess the natural capital as it is and how it can be improved (by means of scenarios analysis).<br>▪ Suggesting and implementing interventions for natural capital enhancement to reach bioclimatic control.<br>▪ Evaluating the achieved benefits of implemented interventions.<br>TRL: Lab or in-house demonstration (4) --> TRL: Market introduction (8) | ▪ Policy makers<br>▪ Urban planners<br>▪ Construction companies and developers<br>▪ Environmental and forestry scientists<br>▪ Citizens |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| B2.1 Overcoming barriers to scale up brownfield development and land reuse<br>B2.2 Scaling up of reusing private and public spaces<br>B2.3 Circular economy in urban transport systems | B2.4 Urban farming to provide ecosystem services, food, water storage and cooling, climate mitigation/ adaptation<br>B2.5 Historical cultural heritage and natural capital enhancement |

### *Subprogramme B3: Circular economy considerations in water supply and treatment systems*

**Rationale for the subprogramme**

One of the biggest barriers to circular economy transition from the water supply and management perspective is the lack of infrastructure to implement integrated water resource management. Initiatives exist on water optimisation in industry and agriculture, and some greywater reuse in commercial/residential applications, however they need to be scaled. This subprogramme is necessary to begin the systemic shift towards integrated water resource management at a wider scale, as well as reduce stress to natural water sources as outlined in the EU Green Deal.

As there are many existing initiatives on water reuse and process optimisation in industry, water reuse and nutrient capture in agriculture, and greywater reuse systems in commercial/residential areas. But most of them are at piloting and demonstration stage, with some at public-private partnership stage. What is needed is a massive expansion of these initiatives for market introduction in EU cities. This should involve development and implementation of sustainable business models, greater industry participation and overcoming social/behavioural challenges where relevant/applicable. In some cases, there is also a need to fundamentally change urban infrastructure. What also tends to be missing is policy – existing initiatives demonstrate the viability of the technology and methods, but policy gaps to upscale them and open the market.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **B3.1 Market introduction of existing pilots and demonstration initiatives on water cascading, wastewater reuse and nutrient recycling**<br><br>This should involve:<br>▪ Inventory or review of existing initiatives and good practices (databases already exist). Such initiatives include wastewater reuse and nutrient recycling from wastewater sludge in industry, agriculture and urban centres (commercial and housing).<br>▪ Market and business analysis of relevant good practices based on specific EU urban contexts (i.e. need to narrow down on geography to identify local needs first).<br>▪ Investigate innovative policy interventions to bring these initiatives to market and expand them. This may include financial and investment instruments.<br>▪ Design programme or project for market introduction and expansion of these initiatives where they do not already exist. This may also consider schemes such as the EU environmental technology verification scheme - to enhance such tools, raise their visibility and set up respective good practices on green public procurement that take existing environmental voluntary schemes into account.<br>▪ Demonstration at the system level especially including non- technical barriers.<br><br>TRL: Lab or in-house demonstration (3) - (4) --> TRL: Market introduction (7) - Scaling (9) | ▪ Economists and industry experts<br>▪ Environmental engineers, utility engineers<br>▪ Policymakers<br>▪ Environmental policy researchers and academics<br>▪ Industry and utility managers<br>▪ Consumers and downstream users (where relevant) |
| **B3.2 Water type separation and infrastructural changes to water supply and treatment systems**<br><br>This could involve policy innovations to standardise water types and flow separation and associated infrastructural changes to manage water types accordingly in urban systems. This should consider local contexts including resource availability and scarcities e.g. of a system from (Novotny, 2010): | ▪ Civil, environmental, utility, urban engineers<br>▪ Policymakers |

- Black water: containing biodegradable organic matter for energy and fertiliser recovery
- Yellow (urine) water: containing unoxidised nitrogen and phosphorus for nutrient recovery
- Grey water: from laundry, bath and kitchen that can be treated for non-potable reuse
- White water: containing surface street and highway runoff with toxic and carcinogenic compounds, metals, PAHs, petroleum hydrocarbons, etc. for stormwater treatment
- Blue water: clean water for potable use

Reclamation and reuse for above types:

- Water recycling: grey, white and blue, including rainwater recycling
- Fertiliser recovery: yellow and black
- Biogas and organic fertiliser/soil conditioner: black
- Irrigation: treated black, yellow, white and blue
- Raw water for water supply: white and blue

TRL: Basic research (1) - (2) --> TRL: Field pilot (5) - (6)

- Environmental policy researchers and academics
- Industry and utility managers
- Consumers and downstream users (where relevant)

**Subprogramme timeline**

| Period & Activities |
| --- |
| **Year 1-4** |
| B3.1 Market introduction of existing pilots and demonstration initiatives on water cascading, wastewater reuse and nutrient recycling |
| B3.2 Water type separation and infrastructural changes to water supply and treatment systems |

## *Subprogramme B4: Shifting towards circular water systems in buildings*

**Rationale for the subprogramme**

Citizens play a pivotal role in circular economy transition, not only in terms of acceptance but also in active participation. Many circular economy-related initiatives have focused on more on industrial and commercial water use and less at the household level. Water supply and management in a circular economy requires both infrastructural changes to buildings and residences as well as to the behaviour of the people who use them. Therefore, this subprogramme is important to ensure systemic shift for water in circular economy from both the technical and social angles. One option to involve the citizens could be to use PPPP (Public-Private-People Partnerships) to encourage the shift towards a circular economy.

To fulfil the objective in this subprogramme, we considered what is needed to shift towards circular urban water systems, and what are the possible contributions of citizens in this process. Overall, it requires infrastructural overhauls to implement integrated water system management (e.g. systems to separate water types (water cascading), nature-based solutions for water treatment and supply) and the introduction of digital technologies for smart water management. Moreover, retrofitting and renovating existing commercial and residential buildings (old and modern) is also essential. Policies and urban master planning for integrated water system management in new buildings and urban development are important as well assessment technologies and tools at household and building level for water supply and treatment (e.g. rainwater capture) – development and scaling.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **B4.1 Review of Integrated Water Resource Management (IWRM) and innovative water efficiency cases in commercial and residential buildings**<br>This activity involves:<br>▪ Conducting inventories of IWRM initiatives and their success factors, failures, lessons learned. This can include both desk research and interviews with practitioners of initiatives programmes studied.<br>▪ Analysing the above factors in relation to their context.<br>▪ Analysing gaps and barriers for IWRM in EU cities, the role of citizen engagement and participation.<br>▪ Developing recommendations for overcoming the gaps and barriers especially from a citizen engagement, participatory and social perspective.<br>▪ Identifying measures especially prioritising short-term measures and solutions to existing problems.<br>Desired TRL: N/A | ▪ Water management researchers and academics<br>▪ Input/data from urban planners, policymakers, citizens, economics and social experts |
| **B4.2 Engaging citizens in scaling up integrated water management in buildings/local level**<br>This activity involves:<br>▪ Linking to and leveraging on the outcomes of the above activity, focusing on EU cities.<br>▪ Implementing or upscaling integrated water management methods such as greywater capture and reuse systems, rainwater capture, making water consumption more efficient and preventative, etc.<br>▪ Providing the technologies and incentives to scale this up – including information and public engagement campaigns, policies and financial incentives. | ▪ Urban planners<br>▪ Municipal policymakers<br>▪ Citizens (at building or community level)<br>▪ Housing corporations<br>▪ Property developers |

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| ▪ Expanding understanding of the gaps and barriers of both traditional and novel water management technologies and approaches, and solutions to overcome them, especially from a citizen engagement perspective.<br>▪ Developing PPPP (Public-Private-People Partnerships) to encourage the shift towards a circular economy.<br>Desired TRL: Market introduction (7) - (8) | ▪ Ecologists and water management experts<br>▪ Behavioural and social scientists<br>▪ Environmental economists |
| **B4.3 Engagement of citizens in integrated water resources management in new urban development**<br>This activity involves:<br>▪ Based on the findings of the first and second activities, developing and implementing the levers for successful citizen participation in Integrated Water Resource Management (IWRM) and piloting them in new urban development projects.<br>▪ Targeting both commercial and residential development projects. The progress and learnings should be monitored and analysed to improve the understanding of gaps and potential solutions for future projects.<br>▪ Integrating communication aspects to ensure that the results are recorded, communicated and exploited.<br>▪ Developing PPPP (Public-Private-People Partnerships) to encourage the shift towards a circular economy.<br>Desired TRLs: Field pilot (6) to Market introduction (7) - (8) | ▪ Urban planners<br>▪ Municipal policymakers<br>▪ Citizens (at building or community level)<br>▪ Housing corporations<br>▪ Property developers<br>▪ Ecologists and water management experts<br>▪ Behavioural and social scientists<br>▪ Environmental economists |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| B4.1 Review of integrated water resource management (IWRM) and innovative water efficiency cases in commercial and residential buildings | B4.2 Engaging citizens in scaling up integrated water management in buildings/local level<br>B4.3 Engagement of citizens in integrated water resources management in new urban development |

### 3.1.1 Pilot Joint Call – Circular Cities

In joint programming initiatives, programme owners should seek to cluster funding programmes under shared circular economy objectives. The Pilot Joint Calls provide examples of how programme owners can collaborate in joint programming using the SRIA. They are intended to complement, align and valorise already existing initiatives, and focus investment in filling the gaps and merging the isolated best practices. In this section an example joint call is provided, followed by an example project, to demonstrate the types of activities that could be implemented under the calls. The R&I activities should focus on filling the technological and non-technological gaps, including the technical, economic and social innovation needed to achieve the transition to circular economy. When collaborating on joint programming, programme owners should also emphasise the exchange of best practices and lessons learned from the implementation of the programmes. Continuous communication and exchange on programme implementation should also take place to avoid the unnecessary duplication or overlap of initiatives and to build strategically on past activities.

**Rationale for this pilot joint call:** Achieving the vision of a circular society requires adapting existing infrastructures and developing new ones that align with circular solutions, create new values and address the many challenges of unsustainable urban development. The new EU Circular Economy Action Plan identifies the importance of circular economy in the creation of new jobs. The European Green Deal emphasises the importance of dialogue with citizens and their inclusion in sustainable urban development work for climate change mitigation, as well as the central role of cities in facilitating this.

The Circular Cities pilot is in line with the above visions and strategies, especially by focusing on the closer engagement of citizens and enabling the conditions needed for implementing circular solutions for products and materials. The pilot employs a multidisciplinary approach for addressing technical, economic and social innovation challenges while fostering innovation in the respective domains.

**How innovation is integrated:** Measures to improve waste management systems have traditionally been focused on technical solutions and infrastructural developments, while somewhat to a lesser degree on raising awareness and social campaigns. The synergies between technological/infrastructural developments with the adequate engagement of citizens and addressing behavioural issues have often been out of sync. The transition to circular economy is not possible without an extensive engagement of citizens enabling them with behavioural knowledge and information on how to use the available resource management systems and infrastructures.

***The aim of this pilot joint call is to improve the coupling of citizens' participation with new initiatives, new market and technological solutions and infrastructural developments to enhance the effectiveness of material and product circular solutions in an urban context.***

**EXAMPLE JOINT CALL: ENABLING URBAN CIRCULARITY AND INCREASING CITIZEN ENGAGEMENT IN CIRCULAR SOLUTIONS**

*(This is an example of a joint call that can be created by programme owners under the Circular Cities joint programme.)*

**Topics covered:** Urban area, waste, plastics, raw materials, construction and demolition materials, chemicals, value chains, waste.

**Description:**

The objective of this call is to facilitate and promote the transition to circular economy in urban areas in line with existing sustainable urban development initiatives. Specifically, the objectives are:

- To enable urban circularity and increasing citizen engagement in circular solutions, and
- To enhance circular economy and natural resource management in urban areas.

**The expected impacts of this call are:**

- Reduced use of resources and related environmental impacts through innovations enabling better infrastructure and the engagement of the citizens;
- Decreased consumption of virgin and non-renewable materials.

**Desired actors involved:** This call is open for application to public and private actors, service and system designers, city planners, research institutes and consumers' organisations. Other key stakeholders that should be engaged/consulted (but not necessarily funded) in projects are policy makers.

**Locations/scale of application:** Regional level

**TRL levels covered:** The target TRL of this project is TRL 3-5 (lab or in-house demonstration) and TRL5-6 (field pilot)

**This joint call contributes to these SRIA objectives:** Circular Cities Objective 1: To enable urban circularity and increasing citizen engagement in circular solutions

## EXAMPLE PROJECT: *CREATING CIRCULAR INFRASTRUCTURE AND ENGAGING CITIZENS IN REUSE*

*This is an example of a project under the above joint call: "Enabling urban circularity and increasing citizen engagement in circular solutions".*

**Description:**

The aim of the project is to enable circularity and increase citizens' engagement in circular solutions through reuse in urban areas.

The project targets long-term environmental benefits including climate mitigation actions and other added value societal benefits through waste minimisation strategies such as material reuse, product lifetime extension and new applications including infrastructural adjustments and citizens' engagement. Holistic and transdisciplinary projects are encouraged in both technical and nontechnical domains. Focus on material recycling and energy recovery are not the focus of this project.

The project suggests strategic activities to increase circularity in urban areas. Its key focus is on:

- Mapping and evaluating the existing initiatives, infrastructures (including digital and non-digital) and successful examples of citizens' engagement in reuse of products and/or materials though, e.g. product design/construction for reuse, collection systems, second-hand markets, digital systems, etc.;
- Developing and implementing measures to engage and incentivise citizens and build consumers' acceptance of circular practices;
- Testing and implementing demonstration projects.

**Location(s) of project implementation:** Regional level.

**TRL levels:** The target TRL of this project is TRL5-6 (field pilot).

**This project will be implemented by a combination of the following groups:** engage and consult with key stakeholders including (but not necessarily limited to) municipalities, private and public waste management companies, repair actors, second-hand actors, academics (social scientists, behavioural economists, psychologists, engineers), producers and retailers, designers and consumer organisations.

Basis of the project from the Circular Economy SRIA:

**Subprogrammes:**

- Circular cities – Subprogramme A1: Infrastructure to enable circular material and product flows
- Circular cities – Subprogramme A2: Citizen participation in circular material and product flows

**Innovation fields:**

- Urban Areas (1): Citizen involvement for circular and sharing economy
- Urban Areas (2): Circular systems for used products
- Waste (3): Setting up circular business models to extend product lifespan.
- Urban Areas (5): Advanced waste management systems for circularity
- Raw Materials (5): Optimising value per kg of raw material use

## 3.2 CIRCULAR INDUSTRIES

To transition to the circular economy, industrial processes need to shift towards sustainable production and adopt innovative technologies and tools that are resource efficient. This joint programme focuses on the development of new integrated solutions and the upscaling of existing tools and solutions that already exist at small scale, to be implemented in factories, industrial areas and productive sectors (e.g. agro-industry, metallurgy and textiles, amongst others).

This is strongly in line with The European Green Deal which identifies disruptive innovative technologies a key part of the long-term path to sustainable growth. In this regard, the goal of this joint programme is to facilitate the transition of industries to the circular economy through research and innovation. Specifically, the objectives of this joint programme are:

1. To develop new technologies, quality standards and analytic methods for new materials production and resource and waste characterisation,
2. To enable industrial symbiosis networks and foster digitalisation to master the complexity of products, processes and systems,
3. To raise awareness of industrial ecology by promoting new/better design and use of products and better re-use of materials already in circulation, and
4. To reduce the carbon emissions of companies.

The activities identified in this joint programme concern innovation in product design, production processes, the efficient use and management of resources, reduction of emissions and waste, valorisation of process waste, collaborative exchange between different industries and cross-sector collaboration (e.g. through industrial symbiosis), sustainable and circular management of industrial areas, redevelopment of industrial areas and the conversion of existing factories to the circular economy.

The expected impacts of this joint programme include:

- Greater shift towards circular industrial production, characterised by increased use of secondary raw materials, material circularity and cycling of energy;
- Increased availability of knowledge, data and standards to facilitate circular economy in industrial production; and
- Reduced consumption of material and energy and emissions of air pollution and greenhouse gases, reduced impact to environmental and human health due to industrial production and industrial activities.

The SRIA aims to address the transition to circular economy, which is the pre-requisite to reach self-sufficiency in the EU and a driver for climate change mitigation. The potential for self-sufficiency is part of the different pilot joint calls in the SRIA. In the Circular Industries joint programme, this is addressed by industrial symbiosis-related activities.

## Objective A: To develop new technologies, processes, quality standards and analytic methods for new materials production and for resource and waste characterisation

### *Subprogramme A1: Developing new technologies for new materials production*

**Rationale for the subprogramme**

This subprogramme is strongly in line with The European Green Deal, specifically new technologies, sustainable solutions and disruptive innovation, which are considered to be *"critical to achieve the objectives of the European Green Deal"*. It dedicates a section to "mobilising research and fostering innovation" in response to the challenge "to keep competitive advantage in clean technologies by increasing significantly the large-scale deployment and demonstration of new technologies across sectors and across the single market, building new innovative value chains" (European Commission, 2019).[10]

To fulfil the objective in this subprogramme, developing innovative processes to sustainably produce chemicals and materials, reducing the dependence from oil and improving the recyclability of materials were considered. This requires measures such as the development of innovative biotechnological processes for the production of chemicals as well as plastic materials, produced from renewable resources. The integrated chemical footprint needs to be considered at the front of innovation in businesses and business decisions in order to (i) reduce the chemical impact of production processes; (ii) limit the circulation of substances of concern for human health and the environment, and (iii) facilitate safe product recycling without perpetuating the presence of such substances on the market in observance of industrial symbiosis principles. Industrial symbiosis is the process by which waste or by-products of an industry or industrial process become the raw materials for another. The application of this concept allows materials to be used in a more sustainable way and contributes to the creation of a circular economy.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **A1.1 Development of innovative biotechnological processes for chemicals production**<br>This activity involves:<br>▪ Conducting research to develop novel biochemical production processes, including biomimicry.<br>▪ Producing sustainably fine chemicals with added value as building blocks.<br>▪ Producing advanced intermediates or active ingredients as starting materials for specialty chemicals, especially pharmaceuticals, biopharmaceuticals and agrochemicals.<br>TRL: Basic research (2) --> TRL: Field pilot (5) | ▪ Chemical companies<br>▪ Research centres with expertise in chemistry and biotechnology<br>▪ Engineering companies<br>▪ Universities |
| **A1.2 Pilot, demonstration and upscaling of innovative biotechnological processes for chemicals production**<br>This activity involves:<br>▪ Piloting, demonstrating and scaling up the innovations developed in activity 1 above.<br>TRL: Field pilot (5) --> TRL: Scaling (9) | ▪ Chemical companies<br>▪ Industry actors, producers, manufacturers, (original equipment manufacturers (OEMs), original design manufacturers |

[10] European Commission (2019) The European Green Deal. Brussels: Office for Official Publications of the European Communities

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|---|---|
| | (ODMs), parts manufacturers)<br>▪ Engineering companies |
| **A1.3 Development of innovative biotechnological processes for plastics production**<br>This activity involves:<br>▪ Conducting research to produce novel biochemical production processes, including biomimicry, to sustainably produce plastics, either recyclable or bio-degradable.<br>▪ Considering existing technologies and innovations of bio-based and biodegradable plastics and developing solutions to overcome their shortcomings (e.g. by addressing collection and sorting infrastructure, communication and knowledge building, shifting consumer behaviour).<br>TRL: Basic research (2) --> TRL: Field pilot (5) | ▪ Chemical companies<br>▪ Research centres expert in chemistry, polymers and biotechnology<br>▪ Engineering companies<br>▪ Universities<br>▪ Downstream actors including consumers, waste management sector, municipalities |
| **A1.4 Pilot, demonstration and upscaling of innovative biotechnological processes for plastics production**<br>This activity involves:<br>▪ Piloting, demonstrating and scaling up innovations developed in activity 3 above.<br>TRL: Field pilot (5) --> TRL: Scaling (9) | ▪ Chemical companies<br>▪ Industry actors, producers, manufacturers (OEMs, ODMs, parts manufacturers)<br>▪ Engineering companies<br>▪ Downstream actors including consumers, waste management sector, municipalities |
| **A1.5 Developing processes and eco-design to substitute hazardous substances**<br>This activity involves:<br>▪ Developing new processes and encouraging product eco-design for substituting hazardous substances, while retaining key properties.<br>▪ Hazardous chemical substitution should place special focus on the fields of: waterproof and oil proof materials, preservatives and antimicrobials, plasticisers, and protective surface treatments.<br>TRL: Basic research (2) --> TRL: Field pilot (5) | ▪ Chemical companies<br>▪ Industry actors, producers, manufacturers<br>▪ Research centres expert in chemistry and material science<br>▪ Engineering companies<br>▪ Universities |

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| **A1.6 Pilot, demonstration and upscaling of hazardous substance management in new materials production**<br>This activity involves:<br>▪ Piloting, demonstrating and scaling up innovations developed in activity 5 above.<br>▪ Developing communication tools and methods to inform consumers.[11]<br>TRL: Field pilot (5) --> TRL: Scaling (9) | ▪ Chemical companies<br>▪ Engineering companies<br>▪ Industry actors, producers, manufacturers (OEMs, ODMs, parts manufacturers) |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| A1.1 Water type separation and infrastructural changes to water supply and treatment systems<br>A1.2 Pilot, demonstration and upscaling of innovative biotechnological processes for chemicals production<br>A1.3 Development of innovative biotechnological processes for plastics production | A1.4 Pilot, demonstration and upscaling of innovative biotechnological processes for plastics production<br>A1.5 Developing processes and eco-design to substitute hazardous substances<br>A1.6 Pilot, demonstration and upscaling of hazardous substance management in new materials production |

[11] This can be linked to traceability-related activities in the Closing the Loop joint programme - Subprogramme 2.1 Circular design and technical development for human and environmental health.

### *Subprogramme A2: Developing quality standards and analytic methods for materials production and characterisation*

**Rationale for the subprogramme**

This subprogramme is strongly in line with the European Green Deal, specifically to develop new technologies, sustainable solutions and disruptive innovation which are considered to be critical to achieve the objectives of the European Green Deal. The EU's trade policy, mentioned in the European Green Deal, facilitates trade and investment in green goods and services toward an ecological transition. In particular all chemicals, materials, food and other products that are placed on the European market must fully comply with relevant EU regulations and standards. Developing quality standards and analytic methods for materials production and characterisation can help to improve the composition of materials in line with a green transition of products.

This subprogramme focuses on developing quality standards and analytic methods for material production and characterisation. It requires improving the awareness about what is on the market and in circulation. It is also important to encourage the use of safe and non-hazardous substances in order (i) to limit the circulation of substances of concern for human health and the environment, and (ii) to facilitate safe product recycling without perpetuating the presence of such substances on the market. A better knowledge of materials composition and properties is essential. To achieve the objective, building greater awareness about the need to correctly dispose of old and damaged products from a materials perspective is required.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **A2.1 Promotion of traceability**<br>This activity involves:<br>▪ Promoting traceability and transparency in value chains in terms of resource intensity, material composition/process material use, and lifecycle impacts by using technologies e.g. blockchain technology or radio-frequency identification (RFID) and other industry 4.0 concepts. The information should be used as a proof of a certain level of quality standard and reduce the analytical efforts at the end-of-life.<br>▪ Increasing sectoral and cross-sector knowledge and innovation networks which address the capacity to shift towards circularity.<br>▪ Improving knowledge and filling implementation gaps in different regions of Europe.<br>▪ Involving SMEs in digitalisation and circular economy research and projects.<br>TRL: Field pilot (6) --> TRL: Scaling (9) | ▪ Manufacturing, chemical, primary raw materials, and recycling companies<br>▪ Research organisations<br>▪ Universities<br>▪ Experts in: product design, service design, material experts, Enterprise Resource Planning (ERP) systems, business-to- business (B2B) and business-to-consumer (B2C) digital platform/app developers<br>▪ Circular business model developers<br>▪ Consumer organisations |
| **A2.2 Chemical footprint considerations at the front end of business innovation**<br>This activity involves:<br>▪ Integrating chemical footprint considerations at the front end of innovations in business research and development and business decisions.<br>▪ Addressing eco-design to safe and efficient processes for depolluting and disassembling complex products, aiming at concentrating material rates and enabling highly selective recycling. | ▪ Chemical companies<br>▪ Industry actors, producers, manufacturers<br>▪ Research centres expert in chemistry and material Science<br>▪ Engineering companies |

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| ▪ When considering hazardous chemical substitution, special focus should be placed on the fields of waterproof and oilproof materials, preservatives and antimicrobials, plasticisers and protective surface treatments.<br><br>TRL: Field pilot (6) --> TRL: Scaling (9) | ▪ Universities |
| **A2.3 Developing non-destructive analytical methods to achieve better knowledge of materials composition and properties**<br><br>This activity involves:<br><br>▪ Conducting research and development on analytical methods to build knowledge on material composition and their properties.<br><br>▪ Research fields should be concentrated in the areas of analytical chemistry, material science and electronics with a focus on instrumental analysis.<br><br>TRL: Basic research (2) --> TRL: Field pilot (5) | ▪ Chemical companies<br><br>▪ Research centres expert in material science and/ or analytical chemistry Universities |
| **A2.4 Upscaling the use of new analytical techniques and instruments for characterisation**<br><br>This activity involves:<br><br>▪ Promoting instruments and software capable of using the analytical instrumental techniques developed in the above activities for characterisation.<br><br>TRL: Field pilot (5) --> TRL: Scaling (9) | ▪ Chemical companies<br><br>▪ Research centres expert in Electronics<br><br>▪ Experts in analytical chemistry and material science<br><br>▪ Universities |
| **A2.5 Expansion of extended producer responsibility systems to other sectors**<br><br>This activity involves:<br><br>▪ Developing cost-efficient and effective extended producer responsibility (EPR) systems.<br><br>▪ Developing product stewardship plans for the collection of used products and fostering reverse supply chain activities.<br><br>▪ Fostering knowledge and awareness on EPR and reverse supply chain systems across sectors that do not currently have EPR systems.<br><br>▪ Implementing EPR and reverse supply chain systems in sectors including detergents and cosmetics.<br><br>Desired TRL: N/A | ▪ Companies in target sectors for fostering EPR systems<br><br>▪ Research organisations<br><br>▪ Competent authorities<br><br>▪ Circular business model developers |

**Subprogramme timeline**

**Period & Activities**

| Year 1-4 | Year 5-10 |
|---|---|
| A2.1 Promotion of traceability | A2.4 Upscaling the use of new analytical techniques and instruments for characterisation |
| A2.2 Chemical footprint considerations at the front end of business innovation | A2.5 Expansion of extended producer responsibility systems to other sectors |
| A2.3 Developing non-destructive analytical methods to achieve better knowledge of materials composition and properties | |

### *Subprogramme A3: Developing new technologies for resource and waste characterisation*

**Rationale for the subprogramme**

The European Green Deal emphasises the importance of new technologies, sustainable solutions and disruptive innovation, which are key areas in addressing waste management issues and improving waste reduction. In this process, waste characterisation is also critical to scale up the valorisation and use of waste as a resource. Such actions can support the creation of a robust and integrated single market in the EU for secondary raw materials and by-products, and greatly benefit European companies and producers. According to the European Green Deal, "this requires deeper cooperation across value chains, as in the case of the Circular Plastics Alliance. The Commission will consider legal requirements to boost the market of secondary raw materials with mandatory recycled content (for instance for packaging, vehicles, construction materials and batteries). To simplify waste management for citizens and ensure cleaner secondary materials for businesses, the Commission will also propose an EU model for separate waste collection" (European Commission, 2019).[12] This subprogramme focuses on developing technologies for resource and waste characterisation to facilitate the development of the sustainable product and waste reduction policies outlined in the European Green Deal.

This subprogramme focuses on developing new technologies for resource and waste characterisation. It requires measures such as ensuring raw material (RM) security and industry competitiveness by a proper usage of primary RM from EU, indirectly supporting the development of the secondary RM industry (forward and backward integration for maintaining metallurgy infrastructure), mapping and valorising secondary feedstock, achieving a better knowledge of waste composition, gaining an overview of the sectoral and cross-sectoral circular economy knowledge, filling capacity and gaps by digitalisation, improving the quality of waste collection to optimise the recycling of resources and efficiently using secondary RMs. The materials industries and metallurgy industries need to know the character of the secondary RMs to develop the appropriate processes and ensure RM security.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **A3.1 Upscaling systems for widescale secondary raw material use**<br>This activity involves:<br>▪ Developing scalable solutions for exploring, creating inventories and sharing information about material streams and potential sources of secondary raw material extraction in the EU, including urban and landfill mining as well as industrial residues.<br>▪ Sustainable management of biomass feedstocks from co- products, side streams and residual streams.<br>▪ Developing sustainability criteria and circularity metrics for different biomass types.<br>▪ Developing safe and efficient processes for depolluting and disassembling complex products (including WEEE), aiming at concentrating material rates and enabling highly selective recycling.<br>▪ Developing efficient and eco-friendly sorting, disassembling, separation and recovering processes for complex products.<br>▪ Considering aspects including the cost-efficiency of valuable elements with low-concentration, robust and low-environmental impact detection and extractive processes (e.g. real-time feedback, automation, digital simulation etc.), delivering secondary feedstocks, and feasible multi-material recovery. | ▪ Manufacturing companies<br>▪ Experts in: product design, service design, material experts<br>▪ Software companies<br>▪ Research organisations<br>▪ Universities<br>▪ Circular business model developers<br>▪ Engineers |

[12] European Commission (2019) *The European Green Deal*. Brussels: Office for Official Publications of the European Communities

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|---|---|
| ▪ Developing advanced, cost-effective industrial and urban wastewater treatment technologies characterized by the recovery of valuable products and pollutants (e.g. metals, minerals, nutrients and chemicals), microplastic filtration/treatment and water capture and reuse from agricultural liquid and solid wastes. This may also involve increasing operational efficiency of wastewater treatment facilities<br><br>TRL: Lab or in-house demonstration (4) --> TRL: Scaling (9) | |
| **A3.2 R&D in analytical chemistry and in electronics focused on instrumental analysis**<br><br>This activity involves:<br><br>▪ Developing more sensitive and accurate analytical techniques for resource and waste characterisation.<br><br>TRL: Basic research (2) --> TRL: Field pilot (5) | ▪ Chemical companies<br>▪ Research centres expert in electronics<br>▪ Experts in analytical chemistry and material science<br>▪ Universities |
| **A3.3 Development of cost-efficient extractive and processing technologies for improved separation of by-products of ore mining in the EU within the supply chain of materials in CE**<br><br>This activity involves:<br><br>▪ Focusing on EU deposits of critical raw materials with potential by-products to be considered as drivers in advanced technologies, such as for low carbon industry, e- mobility, communication and health care.<br>▪ Mapping the latest developments and technological conceptualisations in extractive technologies, focusing on key developments in extraction and processing.<br>▪ Scaling up the latest innovations in extractive and processing technologies by measures including digital twins that permit techno-economic and environmental impacts of the complete CE system. Considering other sustainability and strategic aspects including cost efficiency, social licence to operate and environmental impacts in the process.<br><br>TRL: Lab or in-house demonstration (3) --> TRL: Field pilot (6) | ▪ Mining companies<br>▪ Metallurgy companies<br>▪ Research organisations<br>▪ Universities |
| **A3.4 Scale up the use of new analytical instrumental technique for characterisation**<br><br>This activity involves:<br><br>▪ Promoting instruments and software capable to use the analytical instrumental technique developed in the above activities for characterisation.<br><br>TRL: Field pilot (5) --> TRL: Scaling (9) | ▪ Chemical companies<br>▪ Research centres expert in electronics<br>▪ Experts in analytical chemistry and material Science |

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| **A3.5 New agile processing technologies that adaptively operate within a robust smelter system**<br><br>This activity involves:<br>▪ Developing technologies and processes to adjust kiln design and operations in smelters to feed primary and secondary sources in terms of obtaining better yields and separation of by-products from carrier metals.<br>▪ Considering the quality requirements of products and materials.<br>▪ Considering improvements in decreasing emissions and effluents meeting environmental constraints.<br><br>TRL: Lab or in-house demonstration (4) --> TRL: Scaling (9) | ▪ Metallurgy companies<br>▪ Plastic companies<br>▪ Secondary or higher education establishments/ research organisations |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| A3.1 Upscaling systems for widescale secondary raw material use<br><br>A3.2 R&D in analytical chemistry and in electronics focused on instrumental analysis | A3.3 Development of cost-efficient extractive and processing technologies for improved separation of by-products of ore mining in the EU within the supply chain of materials in CE<br><br>A3.4 Scale up the use of new analytical instrumental technique for characterisation<br><br>A3.5 New agile processing technologies that adaptively operate within a robust smelter system |

## Objective B: To enable industrial symbiosis networks and foster digitalisation to master the complexity of products, processes and systems

### *Subprogramme B1: Smart Factories - Building SME partnerships, "alliances of interests" and industrial symbiosis networks*

**Rationale for the subprogramme**

This subprogramme is connected to the four 'Green Deal Missions' outlined in the European Green Deal, which focuses on issues related to climate change, oceans, cities and soil. They will bring together stakeholders and form partnerships with industries and member states to conduct research and innovation on transport, batteries, clean hydrogen, low-carbon steel production, circular bio-based sectors and the built environment. The EU will put emphasis on supporting its immediate neighbours, with partnership and new networks really close to an *"alliances of interests"* concept. There is a strong recognition that close collaboration with the EU's immediate neighbours is fundamental to circular economy transition. As such, partnerships on environment, energy and climate with the "Southern Neighbourhood and within the Eastern Partnership" is envisaged. Finally, the EU Industrial Strategy plans to mobilise the industrial sector and all the value chains towards a model of sustainable and inclusive growth, ensuring efficient and clean resource cycles. This subprogramme is intended to support these initiatives from the circular economy research and innovation perspective.

To fulfil the objective in this subprogramme, enabling and promoting the collaboration between SMEs in industry to enable industrial symbiosis networks was considered. This requires measures such as efficient information sharing about secondary resources (subproducts, waste and all possible secondary raw materials), digitalisation of SMEs for circular economy, developing simulation tools and building infrastructure and facilities for industries to share services and logistics. This subprogramme is inspired by the basic principles of industrial symbiosis in which the resources generated by an industrial process are captured as a 'new' input into another process by one or more other companies, providing mutual benefits.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **B1.1 Efficient secondary resources information sharing**<br><br>This activity involves:<br>▪ Designing models and software for resource matching between industries. This may include designing digital platforms to share secondary resources, residues and by products.<br>▪ Developing solutions to overcome current communication and data-sharing gaps, including approaches to actively broker between companies, and building willingness amongst value chain actors to set up symbiotic exchanges.<br>▪ Promoting and implementing pilot cases through strategic communication and coordination.<br><br>TRL: Field pilot (6) --> TRL: Scaling (9) | ▪ Experts in: product design, service design, material experts, digital platform/app developers<br>▪ Producers (brands and corporations of the products involved)<br>▪ Research institutes<br>▪ IT companies and digital platform providers |

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| **B1.2 Digitalisation of SMEs for circular economy**<br>This activity involves:<br>▪ Introducing digital technologies in SMEs to unlock the potential of circular economy.<br>▪ Simplifying data management in circular economy models where information such as material flows may be constantly exchanged.<br>▪ Considering the potentially limited resources of SMEs and complement existing efforts in developing innovative and supportive policies, and educational and training programs.<br>TRL: Basic research (2) --> TRL: Scaling (9) | ▪ Software companies<br>▪ SMEs<br>▪ Policy makers<br>▪ Producers and recycling companies |
| **B1.3 Development of infrastructure and facilities to upscale industrial symbiosis**<br>This activity involves:<br>▪ Developing infrastructure and building facilities for industries to efficiently share services such as water management, energy, thermal waste, and logistics to support industrial symbiosis.<br>TRL: Field pilot (6) --> TRL: Scaling (9) | ▪ Industrial parks<br>▪ Companies<br>▪ Energy distribution service<br>▪ Competent authorities |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| B1.1 Efficient secondary resources information sharing<br>B1.2 Digitalisation of SMEs for circular economy | B1.3 Development of infrastructure and facilities to upscale industrial symbiosis |

## Objective C: To raise awareness of industrial ecology by promoting new/better design and use of products and better re-use of materials already in circulation

### *Subprogramme C1: Promoting eco-design and eco-processes*

**Rationale for the subprogramme**

This subprogramme is intended to support the Circular Economy Action Plan, highlighting the relevance of eco-design and eco-processes for circular economy acceleration and implementation. In the "Mobilising industry for a clean and circular economy" section of the EU Green Deal, the important role of circular design is discussed. It states that "The circular economy action plan will include a 'sustainable products' policy to support the circular design of all products based on a common methodology and principles. It will prioritise reducing and reusing materials before recycling them. It will foster new business models and set minimum requirements to prevent environmentally harmful products from being placed on the EU market" (European Commission, 2019).[13]

To fulfil the objective in this subprogramme, we considered the potential for eco-design and eco-processes to raise awareness of industrial ecology. This allows minimisation of the environmental impact along products life cycle from the design phase until their end-of-life, without jeopardising (but promoting) their economic feasibility and the minimisation of the environmental impact of production processes. To achieve the objective in this subprogramme, developing advanced remanufacturing processes for safe and efficient material recovery is required. Eco-design according to the principles of industrial ecology supports the design of products that can be easily recovered in a circular perspective which encourage symbiosis between industries. The valorisation of under-utilised infrastructures and their conversion to circular economy hubs is expected to contribute to achieving the goal.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **C1.1 Eco-design and processes that minimise product environmental impact**<br>This activity involves:<br>▪ Developing strategies and tools for designing products that minimise lifecycle footprint, relying on the optimal combination of resource and energy efficiency, use of secondary or substitute materials (especially critical raw materials), design-for-usage, traceability and design-for-recycling.<br>▪ Strongly linking to the Eco-design Directive, Ecolabel Regulation and Extended Producer Responsibility (EPR).<br>▪ Integrating chemical footprint considerations at the front end of innovation.<br>▪ Avoiding the use of substances dangerous for the health and the environment.<br>▪ Focusing on additive manufacturing instead of subtractive manufacturing to boost material efficiency.<br>▪ Improving product robustness, reliability and durability<br>▪ Placing focus on packaging and boosting circularity in terms of recycling and degradability. | ▪ Eco-designer<br>▪ Producers<br>▪ Engineering companies<br>▪ Manufacturing companies |

[13] European Commission (2019) *The European Green Deal*. Brussels: Office for Official Publications of the European Communities

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|---|---|
| ▪ Developing innovative industrial manufacturing solutions that enable minimum resource and energy consumption in the production process, including additive manufacturing, process intensification and quality standards supporting versatile sourcing.<br><br>TRL: Lab or in-house demonstration (4) --> TRL: Scaling (9) | |
| **C1.2 Upscaling of production based on renewable sources**<br><br>This activity involves:<br><br>▪ Developing and upscaling innovative biotechnological processes for producing chemicals and polymers.<br><br>▪ Conducting research to produce novel biochemical production processes, including biomimicry, to sustainably derive fine chemicals with added value as building blocks, and advanced intermediates or active ingredients as starting materials for specialty chemicals, particularly pharmaceuticals, biopharmaceuticals and agrochemicals.<br><br>▪ Addressing biorefineries to shift towards the sustainable production of plastics, either recyclable or biodegradable.<br><br>TRL: Lab or in-house demonstration (3) --> TRL: Scaling (9) | ▪ Eco designer<br><br>▪ Producers<br><br>▪ Engineering companies<br><br>▪ Chemical and biotechnological companies |
| **C1.3 Advanced remanufacturing processes for safe and efficient material recovery**<br><br>This activity involves:<br><br>▪ Developing processes and logistics for safe and efficient collection, disassembly, recovery and reuse of valuable materials, especially for complex, composite and hazardous assemblies.<br><br>TRL: Lab or in-house demonstration (3) --> TRL: Scaling (9) | ▪ Companies<br><br>▪ Research organisations<br><br>▪ Recycling companies<br><br>▪ Smelters (metal recycling)<br><br>▪ Software developers |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| C1.1 Eco-design and processes that minimise product environmental impact<br><br>C1.2 Upscaling of production based on renewable sources | C1.3 Advanced remanufacturing processes for safe and efficient material recovery |

## *Subprogramme C2: Promoting re-use, repair and remanufacturing*

**Rationale for the subprogramme**

This subprogramme is directly connected with the new EU Circular Economy Action Plan (CEAP) which includes a sustainable products policy to improve the design, production and marketing of sustainable products. It also links to the CEAP's intentions to provide support to circularity design and tools for industries to manage their supply chains, establish minimum requirements to prevent the introduction of harmful products to the EU market and prioritise reuse and repair before recycling. Finally, this subprogramme is also in line with the previous version of the CEAP, by highlighting the relevance of eco-design for circular economy implementation.

To fulfil the objective in this subprogramme, the role of reuse, repair and remanufacturing in industries was considered. This requires measures such as reverse logistic systems, promoting or encouraging the standardisation of parts and components and production processes making repair and remanufacturing less expensive and more efficient, and developing advanced remanufacturing processes for safe and efficient material recovery, in full respect of the principles of industrial ecology.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **C2.1. Development of reverse logistics systems**<br>This activity involves:<br>▪ Promoting and developing environmentally friendly reverse logistic systems, possibly B2B (i.e. service and facilities that are not necessarily owned by the same company), and optimal (i.e. either the products should be reused, repaired, remanufactured or recycled).<br>TRL: Basic research (2) – Lab or in-house demonstration (3) --> TRL: Scaling (9) | ▪ Companies along the product value chain<br>▪ Logistics service<br>▪ Software company |
| **C2.2 Standardisation of components**<br>This activity involves:<br>▪ Standardising product components to facilitate and increase product maintenance during use life (e.g. mobile phone components such as battery, charger, screen). This may also lead to cost savings due to greater economies of scale. Aspects of standardisation may include:<br>  ▪ Consistency in quality<br>  ▪ Ease of maintenance<br>  ▪ Improved capability to reuse spare parts, modular design<br>  ▪ Standardisation of sizing<br>  ▪ Ease of production<br>  ▪ Reduced need to carry stock<br>▪ Mapping existing standardisations, state-of-the-art and the latest innovations.<br>▪ Identifying priority components for standardisation.<br>▪ Establishing guidelines, toolkit and training materials for manufacturing industries.<br>TRL: Basic research (2) --> TRL: Field pilot (6) | ▪ Product designers<br>▪ Manufacturing companies<br>▪ Competent authorities<br>▪ Value chain actors<br>▪ Consumers |

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| **C2.3 Advanced remanufacturing processes for safe and efficient material recovery**<br><br>This activity involves:<br><br>▪ Developing processes and logistics for safe and efficient collection, disassembly, recovery and reuse of valuable materials, especially for complex, composite and hazardous assemblies.<br><br>TRL: Lab or in-house demonstration (3) --> TRL: Scaling (9) | ▪ Companies<br>▪ Research organisations<br>▪ Recycling companies<br>▪ Smelters (metal recycling)<br>▪ Software developers |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| C2.1 Development of reverse logistics systems<br><br>C2.2 Standardisation of components | C2.3 Advanced remanufacturing processes for safe and efficient material recovery |

## Objective D: To reduce the carbon emissions of companies

### *Subprogramme D1: Greenhouse gas accounting and management system (individual company*)*

**Rationale for the subprogramme**

While greenhouse gas accounting and management systems already exist (e.g. US EPA Guide to Greenhouse Gas Management for Small Business & Low Emitters, or the UK's Mandatory Carbon Reporting), the implementation is mostly limited to the largest enterprises, many of which are under the legal obligation to do so. At the same time, medium, small and micro enterprises account for the major share of business activities in the EU. By raising awareness of greenhouse gas (GHG) accounting and managing practices among smaller industries, particularly those with energy or emission intensive processes, the companies can make better informed decisions on whether they should implement GHG management systems considering the advantages and disadvantages..

The development of GHG management systems for smaller enterprises would also contribute to the EU climate strategy and target and climate neutral society in the long run. After all, 50% of GHG emissions are related to material use. GHG reduction can therefore only by realised if material intensity and resource efficiency are also considered. This subprogramme supports smaller enterprises to increase their contribution to the climate change related aspects of the EU Green Deal, EU Circular Economy Action Plan and the new Horizon Europe programme. It targets smaller enterprises in emissions-intensive (direct, indirect and process related) industries: ferrous and non-ferrous metals, cement production, wastewater treatment, chemicals, fertilisers, pulp and paper, food processing and textiles.

To fulfil the objective in this subprogram, the role of GHG accounting and management to reduce carbon emissions in industries was considered. This requires GHG accounting and management becoming a common practice in industries. Companies need to be aware of their responsibility of its GHG emissions and how its GHG emissions are related to energy consumption, efficiency etc. Also, this subprogramme also complies with the principles of industrial symbiosis with certain proposals for saving and reuse of energy, water, materials and by- products. Saving materials means avoiding the energy to produce them, therefore symbiotic solutions between industries can decrease greenhouse gas emissions.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **D1.1 Development of GHG accounting or inventory systems**<br>This activity involves:<br>▪ Developing GHG inventory and accounting practices (e.g. maintaining records of energy consumption, process GHG emissions) and finding solutions to make them cost-efficient for SMEs.<br>▪ Developing guidelines and toolkits (considering ISO 14064).<br>▪ Mapping and presenting GHG emission data of the industry (according to the target audience).<br>▪ Preparing training materials and conducting capacity building activities on establishing GHG accounting systems.<br>Desired TRL: N/A | ▪ Companies (prioritising emissions-intensive companies (direct plus indirect and process related): Ferrous and non-ferrous metals, cement production, wastewater treatment, chemicals, fertilisers, pulp and paper, food processing and textiles (excluding the energy industry))<br>▪ Consultants in GHG accounting<br>▪ Competent authorities<br>▪ Investors |

| | |
|---|---|
| **D1.2 Development of GHG management systems**<br><br>This activity involves:<br><br>▪ Promoting and encouraging companies to reduce GHG emissions by periodically setting targets based on their GHG inventory (e.g. improving energy efficiency in production processes).<br><br>▪ Identifying general measures and specific industry measures presenting them accordingly to the appropriate target audiences. Ensuring that such measures are cost-efficient for SMEs and developing incentives for SMEs to replace low efficiency machinery and processes.<br><br>▪ Developing guidelines and toolkits for GHG management and control systems (considering ISO 14064).<br><br>▪ Collecting and sharing best practices.<br><br>▪ Conducting capacity building activities.<br><br>Desired TRL: N/A | ▪ Companies (prioritising emissions-intensive companies (direct plus indirect and process related): Ferrous and non-ferrous metals, cement production, wastewater treatment, chemicals, fertilisers, pulp and paper, food processing and textiles (excluding the energy industry))<br><br>▪ Consultants in energy and production efficiency, etc.<br><br>▪ Competent authorities<br><br>▪ Investors |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| D1.1 Development of GHG accounting or inventory systems | D1.2 Development of GHG management systems |

## *Subprogramme D2: Promoting secondary raw materials market and industry*

**Rationale for the subprogramme**

This subprogramme aligns with areas in the EU Circular Economy Action Plan related to plastics and critical raw materials from the waste management perspective. The activities also reflect the objective: reducing carbon emissions by directly reducing the emissions of material (and manufacturing) industries and indirectly reducing the emissions of extractive and mining industries. At the same time, the subprogramme promotes secondary raw materials (RMs) market platforms in anticipation of the expected influx of supply due to the improvement of the recycling system. The promotion of the reuse product market platform, on the other hand, aims to maximise the use of the products before they enter into the recycling system.

This subprogramme focuses on promoting secondary raw materials market and industry. This requires measures such as raising awareness and acceptance for ensuring cost-competitiveness and the quality of secondary RMs, ensuring transparency, introducing business-to-business market platforms, developing technologies for recovering secondary RMs from waste streams, and ensuring enough collection points, efficient sorting and separation technologies and sufficient recycling infrastructure. This subprogramme also applies the principles of industrial symbiosis through the proposal of resource exchange platforms between two or more industries, by including the shared utilisation of specific equipment or facilities in a symbiotic cooperation.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **D2.1. Technologies for e-waste dismantling, separation and recycling**<br>This activity involves:<br>▪ Mapping existing e-waste dismantling and separation technologies and solutions.<br>▪ Identifying barriers and challenges (e.g. toxic substances, difficulty of separation due to components being glued or soldered together, requiring much manual intervention).<br>▪ Developing cost-effective technologies or solutions (e.g. possible automation).<br>▪ Collaborating with EEE producers, e-waste collecting centres, recycling companies (for e-waste components: metallurgy, plastic etc.).<br>▪ Exchanging and building on experience and lessons learned with EEE producers participating in EPR schemes.<br>Desired TRL: N/A | ▪ Universities and research institutes<br>▪ EEE producers<br>▪ E-waste collecting service companies<br>▪ Metallurgy companies<br>▪ Plastic recycling companies |
| **D2.2 Establishment of secondary market platforms for product reuse**<br>This activity involves:<br>▪ Mapping current reuse paths, identifying potential suppliers (e.g. used/ unwanted products from companies/municipalities) and consumers.<br>▪ Creating virtual market platforms targeting different products for reuse.<br>▪ Considering quality standards of products for reuse.<br>▪ Promoting market platforms to target groups.<br>Desired TRL: N/A | ▪ Companies<br>▪ Public departments |

| | |
|---|---|
| **D2.3 Improvement of e-waste collection infrastructure**<br><br>This activity involves:<br>▪ Mapping existing e-waste collection schemes and central facilities for processing.<br>▪ Identifying barriers and challenges to collection and building sufficient supply volumes<br>▪ Evaluate the required waste volumes for cost-efficient recycling processes (e.g. for minor metals, rare earth); considering economies of scale.<br>▪ Developing effective (cross-border) e-waste collecting schemes.<br>▪ Collaboration between competent authorities, EEE producers, waste collecting service companies, recycling companies (i.e. for e-waste components: metallurgy, plastic etc.) to divert international export of e-waste and build domestic supply volumes.<br>▪ Building on existing knowledge and expert networks.[14]<br><br>Desired TRL: N/A | ▪ Competent authorities<br>▪ Universities and research institutes<br>▪ EEE producers<br>▪ E-waste collecting service companies<br>▪ Metallurgy companies<br>▪ Plastic recycling companies<br>▪ Households and consumers |
| **D2.4 Separation technologies for food contact plastic**<br><br>This activity involves:<br>▪ Developing cost-efficient technologies for separating food contact grade plastic packaging from non-food packaging.<br>▪ Mapping existing sensor and separating technologies and machine learning technologies (e.g. based on the DEXRT (Dual Energy X-Ray Transmission) and the LIBS (Laser Induced Breakdown Spectroscopy) technologies or PRISM (Plastic Packaging Recycling using Intelligent Separation technologies for Materials).<br>▪ Scaling up existing technologies.<br>▪ Developing, piloting and upscaling business models.<br>▪ Ensuring the compliance of the European Food Safety legislation so that recycled plastics can again be used as food contact materials.<br><br>TRL: Field pilot (5) - (6) --> TRL: Scaling (9) | ▪ Competent authorities<br>▪ Universities and research institutes<br>▪ Municipal solid waste plants and recycling companies<br>▪ Sorting/separating technology companies |
| **D2.5 Establishment of secondary market platforms for raw materials**<br><br>This activity involves:<br>▪ Mapping secondary raw material recycling streams, identifying potential suppliers (e.g. end-of-life product collectors, recycled raw material producers) and consumers. Considering that prioritised metal and papers already have rather high demands and maturity.<br>▪ Creating virtual market platforms targeting different secondary raw materials.<br>▪ Considering the quality standards of secondary raw materials.<br>▪ Promoting market platforms to target groups.<br>▪ Ensuring cost-competitiveness compared to primary sources. | ▪ Companies (prioritising emissions-intensive companies (direct plus indirect and process related): Ferrous and non-ferrous metals, cement production, wastewater treatment, chemicals, fertilisers, pulp and paper, food processing and textiles (excluding the energy industry)) |

[14] Such as SCRREEN: http://scrreen.eu/

- Competent authorities
- Investors
- Public departments
- Junkyards

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| D2.1 Technologies for e-waste dismantling, separation and recycling | D2.4 Separation technologies for food contact plastic |
| D2.2 Establishment of secondary market platforms for product reuse | D2.5 Establishment of secondary market platforms for raw materials |
| D2.3 Improvement of e-waste collection infrastructure | |

## *Subprogramme D3: Reducing the carbon and GHG emissions in industrial systems*

**Rationale for the subprogramme**

Climate change mitigation and greenhouse gas reduction is a fundamental part of European sustainability strategies. For example, the European Green Deal aims to transform European society to become fair, prosperous, resource-efficient and competitive by 2050, while remaining carbon neutral and ensuring that economic growth is decoupled from resource use. The EU is also working to ensure that the Paris Agreement remains a key multilateral framework for tackling climate change and is continuing to engage with the G20 economies that are responsible for 80% of global greenhouse gas emissions.

By 2021, the European Commission aims to reduce GHG emissions at the sectoral level by reviewing and proposing to revise relevant climate-related policy documents where necessary. This includes the expansion of new trading sectors in the EU Emissions Trading System, reduction of emissions outside the emissions trading system, and regulations on land use, land use change and forestry. The Commission will also propose to amend the Climate Law to update it accordingly.

The production and use of energy across economic sectors account for more than 75% of the EU's greenhouse gas emissions. At the same time, 60% of GHG emissions from consumption patterns are related to material production and use. There is significant potential in global markets for low-emission technologies and sustainable products and services. Greater focus is also being placed on decreasing material intensity and managing the material footprint of products, as the lifecycle approach is increasingly being adopted.

Improving energy efficiency together with increasing renewable energy and reducing GHG emissions are the three cornerstones of the EU climate strategy. This subprogramme is strongly linked to this and the above developments. It complements the other activities of this joint programme on reducing material footprint in the lifecycle of products with the overall aim of reducing GHG emissions. Specifically, this subprogramme focuses on the energy industry (as the largest GHG emission sector in the supply of electricity and heat to other industries and households) and the carbon capture, utilisation and storage (CCUS) industry (with technologies utilising $CO_2$ as one of the key adaptive measures once GHG is emitted).

To fulfil the objective in this subprogram, we considered direct GHG emission reduction actions for industries. This requires measures such as developing simulation and modelling tools for carbon footprint assessment, improving energy use efficiency, ensuring alternative sustainable energy sources, developing adaptive technologies/systems to reduce industrial emission of GHGs and promoting biological technologies and processes to use $CO_2$.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **D3.1 Promote the adoption of simulation and modelling tool for assessing carbon footprint**<br>This activity involves:<br>▪ Developing and promoting simulation and modelling tools for assessing carbon and GHG footprints along product value chains, including recycling processes, to support decision making processes in business management and improve the understanding on areas for efficiency improvement.<br>▪ Building on existing software and tools for carbon and GHG footprinting.<br>TRL: Lab or in-house demonstration (4) --> TRL: Market introduction (7)- (8) | ▪ Companies along the product value chain of target sectors or products<br>▪ Software developer<br>▪ Research organisations<br>▪ Universities |
| **D3.2 Upscaling energy use efficiency measures**<br>This activity involves:<br>▪ Improving energy efficiency (including waste heat recovery) throughout value chains from raw materials production, manufacturing, logistics, commerce/ | ▪ Energy distributors<br>▪ Engineering companies<br>▪ Energy manager |

| | |
|---|---|
| service to recycling using innovative processes.<br>▪ Taking stock and considering the current state-of-the- art and latest innovations in process efficiency.<br>TRL: Field pilot (5) --> TRL: Scaling (9) | ▪ Energy engineering<br>▪ Research organisations<br>▪ Universities<br>▪ Producers |
| **D3.3 Foster renewable power source**<br>This activity involves:<br>▪ Developing high-efficiency, cost-competitive and durable low-carbon energy sources (for instance photovoltaic, thermal solar, hydroelectric, wind power, and geothermal, etc), including storage technologies (batteries, hydrogen) and infrastructure for transmission and distribution in an environmentally friendly and low carbon foot print way.<br>TRL: Field pilot (5) --> TRL: Scaling (9) | ▪ Energy producers and distributors<br>▪ Engineering companies<br>▪ Energy manager<br>▪ Energy engineering<br>▪ Research organisations<br>▪ Universities |
| **D3.4 Develop technologies for capturing, storage and disposal of GHG**<br>This activity involves:<br>▪ Reducing greenhouse gas emissions by developing technologies or systems for their capture, storage and disposal.<br>TRL: Basic research (1) --> TRL: Market introduction (7)/(8) - Scaling (9) | ▪ Engineering companies<br>▪ Energy manager<br>▪ Energy engineering<br>▪ Research organisations<br>▪ Universities<br>▪ Policy decision-makers |
| **D3.5 Promotion of $CO_2$ utilisation technologies**<br>This activity involves:<br>▪ Promoting biotechnological (microbiological) and chemical process for consuming carbon dioxide.<br>▪ Developing new chemical (new catalyst), enzymatic and microbiological processes to produce fuel, chemicals, polymers and other materials.<br>▪ Scaling up high-temperature co-electrolysis to produce methanol, DME or other high value molecules.<br>TRL: Basic research (2) --> TRL: Scaling (9) | ▪ Chemical companies<br>▪ Energy manager<br>▪ Energy engineering |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| D3.1 Promote the adoption of simulation and modelling tool for assessing carbon footprint | D3.4 Develop technologies for capturing, storage and disposal of GHG |
| D3.2 Upscaling energy use efficiency measures | D3.5 Promotion of $CO_2$ utilisation technologies |
| D3.3 Foster renewable power source | |

### 3.2.1 Pilot Joint Call – Circular Industries

**Rationale for this pilot joint call:** This pilot joint call is intended to develop technologies in factories to achieve higher efficiency and productivity and in parallel, realise the implementation of a smart industrial cluster, connected with other stakeholders in the area (alliances of interests).

This concept is mentioned in the European Green Deal, the mission to "help deliver large-scale changes in areas such as adaptation to climate change, oceans, cities and soil". These missions will bring together a wide range of stakeholders including regions and citizens. Partnerships with industry and Member States will support research and innovation on transport, including batteries, clean hydrogen, low-carbon steel making, circular bio-based sectors and the built environment (European Commission, 2019).[15] This joint call also aligns with the EU's intention to emphasise support to its immediate neighbours, with partnerships and new networks close to an "alliances of interests" concept.

**How innovation is integrated:** The challenge is to promote innovative technologies and tools for the efficient use of resources in industry and for sustainable production. In response, the joint call's approach is based on innovative integrated solutions to be implemented in factories, industrial areas and production sectors (agro- industry, metallurgy, textiles, etc.). This joint call focuses on the micro and meso levels, leaving the macro level approach to production sectors in the pilot joint call of the Closing the Loop joint programme.

**EXAMPLE JOINT CALL: *"DEVELOPMENT OF AN "CIRCULAR ECONOMY APPLICATION" AT MICRO-MESO SCALE FOR THE IMPLEMENTATION OF A SMART INDUSTRIAL CLUSTER, CONNECTED WITH OTHER STAKEHOLDERS IN THE AREA (ALLIANCES OF INTERESTS)"***

*(This is an example of a joint call that can be created by programme owners under the Circular Industries joint programme.)*

**Topics covered:** Raw materials supply, secondary markets, secondary feedstock, recycling and reuse, downgrade material analysis, sustainable production and consumption, resilience, industrial symbiosis, sharing economy, value chain and resource efficiency.

**Description:**

This call aligns with the European Strategy for Raw Materials, WEEE and plastics related strategies, and the EU CEAP.

The projects funded by this call should help achieve the sustainable and circular management of industries either at a micro (single factory) or at a meso (industrial areas, eco parks, etc) level.

Activities should be clearly replicable.

Note: In particular, to replicate a circularity-related project in industrial areas, it could be useful to draw up specific guidelines that trace the path developed in order to make it easier to implement. To map the project, the following main steps are needed:

- identification of the industrial area;
- mapping of production activities
- finding the common services and infrastructures needed; and
- identifying systems necessary to ensure the protection of health, safety and the environment.

The guidelines may be followed by the drafting of an operative handbook that could track all regulatory obligations, bureaucratic constraints, operational procedures and all compliance aspects that make possible synergies between the various actors involved in the industrial area.

These documents will facilitate the reproducibility of such an organisational model in different territorial contexts.

The impacts and other characteristics of potential projects at the micro and meso levels are described separately below.

[15] European Commission (2019) The European Green Deal. Brussels: Office for Official Publications of the European Communities

**MICRO LEVEL**

The activities should include the implementation of technologies and methodologies for resource efficiency.

**The expected impacts of this call are:**

- Technological update of plants
- Increase of social acceptance of new plants
- Decreased of use of hazardous materials in European products according to circular economy indicators
- Reduction of waste production according to circular economy indicators
- Valorisation of materials and products otherwise dispersed and disposed as waste
- Decrease in overall GHG emissions
- Increase of raw materials in the European internal market according to circular economy indicators
- Decrease of raw materials imported in Europe according to circular economy indicators

**Desired actors involved:** The main actors are enterprises (especially SMEs) and circular economy experts.

**Locations/scale of application:** Single plants/ facilities

**TRL levels covered:** The projects at micro level should target a desired level of TRL 7 and include a detailed pathway for reaching TRL 9 at 3 years after the projects' end.

**This joint call contributes to these SRIA objectives:**

- Circular Industries Objective A 'To develop new technologies, quality standards and analytic methods for new materials production and resource and waste characterisation economy'
- Circular Industries Objective C 'To raise awareness of industrial ecology by promoting new/ better design and use of products and better re- use of materials already in circulation'
- Circular Industries Objective D 'To reduce the carbon emissions of companies'

**MESO LEVEL**

The activities should include the implementation of innovative business models based on the circular economy concept. Actions can be supported by using and sharing data among different stakeholders, using selected available tools (e.g. industrial symbiosis platforms) and by the application of collaborative models among stakeholders.

**The expected impacts of this call are:**

- Improved energy and resource efficiency throughout the value chain from raw materials production, manufacturing, logistics, commerce/ service to recycling by innovative processes.
- Reduction of waste production according to circular economy indicators
- Valorisation of materials and products otherwise dispersed and disposed as waste
- Decrease in overall GHG emissions
- Increase in the social acceptance of new industrial plants
- Improved economic and social performance in the area

**Desired actors involved:** The main actors are enterprises (especially SMEs) and circular economy experts and

facilitators. Also, industrial areas, district governing bodies and industry associations should be engaged.

**Locations/scale of application:** All society and economy sectors should be involved.

**TRL levels covered:** The project at meso level should target TRL 7 and include a detailed pathway for reaching TRL 8 at 3 years after the project's end.

**This joint call contributes to these SRIA objectives:**

- Circular Industries Objective B 'To enable industrial symbiosis networks and foster digitalisation to master the complexity of products, processes and systems'
- Circular Industries Objective D 'To reduce the carbon emissions of companies'

## EXAMPLE PROJECT: *CIRCULAR INDUSTRY AND INDUSTRIAL AREAS*

*This is an example of a project under the above joint call: "Development of an "circular economy application" at micro-meso scale for the implementation of a smart industrial cluster, connected with other stakeholders in the area (alliances of interests)".*

**Description:**

The project aims to build the first integrated system for tracking and monitoring the use of raw materials in Europe. An overall raw materials platform will be built, leveraging on existing instruments (i.e. JRC) and connected to product value chains through a digital system, aiming to trace the quantity, purity and use of raw materials in European products. The pilot will include the CRMs first connecting selected European regions and a preliminary study for other raw materials and regions.

The project will include the following steps:

- Development and implementation of innovative technologies in resources, products and waste characterisation
- Development and implementation of innovative and efficient production processes
- Efficient secondary resources information sharing
- Digitalisation of SMEs for circular economy
- Design of sustainable management and utilisation of residual and co-product streams
- Building of infrastructure and facilities for industries to share services and logistics

The project aims to design a circular economy application at small-medium scale, including stakeholders of a given and selected area, engaged in improving their efficiency through technological advances, by following a "cluster" approach. A circular industrial area is characterised by the application of industrial ecology and environmental management systems principles. Generally, this kind of sustainable area aims at the "closing of cycles" of material, water and energy, the pooling of the main environmental services (water, energy, waste) and the optimisation of the organisation of activities that generate impacts on the environment.

The cooperative approach will be reflected by two basic aspects:

- the adoption of collective plants and infrastructure within the industrial area (e.g. consortium cleaner treatment plant, centralised waste storage area, industrial aqueducts, energy production facilities serving the area);
- the identification of a unitary operator that deals with common services within the production area (e.g. collective waste management, energy, security)

The adoption of collective plants and infrastructure can imply technical process and/or plant modification in order to make possible the exploitation of thermal waste and the sharing of water flows, for example. The project will valorise as many streams as possible in an integrated industrial area.

An example of a sector where this project can take place is an industrial area where a sugar factory produces sugar from sugar beets in a symbiosis scheme with other nearby companies. In such a scheme, a biorefinery plant will process the waste of the sugar factory, by carrying out two treatments. First, a pre-treatment of extraction with supercritical $CO_2$ (produced by a nearby chemical plant) of a chemical specialty of pharmaceutical / cosmetic / nutraceutical interest. Then, the waste undergoes an anaerobic digestion for the production of a biodegradable polymer. A pharmaceutical / cosmetic / nutraceutical company will use the chemical specialty for the preparation of high added-value products. Another nearby industry then produces cutting-edge packaging (also for the sugar factory) with the biodegradable polymer produced by the biorefinery.

A chemical company will perform the concentration and purification of the $CO_2$ from air (reduction of greenhouse gases), which is compressed in cylinders for application in chemical plants. This plant will use renewable energy sources and passive systems for the cooling steps. The chemical company will supply $CO_2$ to the biorefinery but also to a carbonated drinks facility. This last company produces carbonated drinks by using the sugar produced by the sugar factory and recovering $CO_2$ from the chemical company. A unitary operator will centrally manage the common waste streams of all companies and the purification plants.

In order to contribute to the production of renewable energy, all buildings will be equipped with photovoltaic panels for the production of electricity, passive systems for heating and cooling and will share the water system for the plants' heat exchangers and services. The presence of a unitary manager of the production sector and representatives of the actors operating within it, will allow the development of a program of environmental improvement of the area, that is a program of actions seen by the participation of several actors, committed to addressing problems of the industrial area, through a

sharing of both financial and human resources. The actions can be both structural and managerial and facilitate the documental management of agreements and various procedural tools for the entire circular community (stakeholders, industries, local authorities...). The central management of the area will provide common services (e.g. logistic, suppliers, transportation) and also the interaction with other stakeholders in the surrounding area (e.g. local authorities, social services, education).

**Location(s) of project implementation:** EU-wide with territorial approach

**TRL levels:** The target TRL of this project is TRL 7

**This project will be implemented by a combination of the following groups:** Enterprise (mainly SMEs), IT companies and software developers, circular economy experts and facilitators

**Basis of the project from the Circular Economy SRIA:**

Subprogrammes:

- Subprogrammme A1: Developing new technologies for new materials production
- Subprogrammme A3: Developing new technologies for resource and waste characterisation
- Subprogrammme B1: Smart Factories - Building SME partnerships, “alliances of interests” and industrial symbiosis networks
- Subprogrammme D1: GHG accounting and management system (individual company)
- Subprogrammme D2: Promoting secondary raw materials market and industry
- Subprogrammme D3: Reduce the carbon/GHG emissions in industrial systems

## 3.3 CLOSING THE LOOP

Closing the loop in production and manufacturing is a key factor to promote the transition to a circular economy, in line with the new EU Circular Economy Action Plan. This is relevant for both materials (e.g. critical raw materials) and products (e.g. plastic packaging, WEEE and tyres), as well as in specific supply chains (e.g. buildings, agro-industry, textiles). Within this challenge, all value chain phases need to be taken into consideration: design, material supply and production, consumption and distribution, maintenance, repair and end-of-life as new production of materials. This type of challenge has a wide territorial extension that is typically on the national and global scales (depending on the geographical area of supply for primary resources).

Based on this, the goal of this joint programme is to support value chains that are closely linked the EU to transition towards the circular economy. Specifically, the objectives of the joint programme are:

1. To ensure that the manufacturing partnerships in Horizon Europe focus on key priorities in circular economy,
2. To address toxic/hazardous substances to human and environmental health in the context of circular economy, and
3. To elaborate and stimulate the adoption of new policies, standard and protocols for governance resource management systems, fostering inter-stakeholder collaboration and integrated management in the entire value chain.

This joint programme focuses on the implementation of synergic actions at macro level involving all the actors of the value chain (designer, producer, distributor, user, end-of-life manager, recycler) in order to identify barriers and remove bottlenecks and broken rings hindering the closure of production loops and implement a sustainable system for all the actors involved. Private actors are also highly relevant, and a possible way for engage them is the activation of Public-Private-People Partnership.

The expected impacts of this joint programme include:

- Improved transparency and availability of information in global and regional value chains and collaboration among upstream and downstream value chain actors;
- Large scale shifts of value chains towards circular production, industrial symbiosis and closure of production loops; engaging non-EU value chain actors and indirectly enabling circular economy transition in countries outside of the EU;
- Increased production and volume of safer products on the European market; and
- Contribution to increasing self-sufficiency in the EU in terms of the security and supply of materials and products.

## Objective A: To ensure that the manufacturing partnerships in Horizon Europe focus on key priorities in circular economy

### *Subprogramme A1: Circular complex product design*

**Rationale for the subprogramme**

This subprogramme was developed in connection with new Circular Economy Action Plan, aligning with the Action Plan's emphasis of eco-design for circular economy implementation, the relevance of the Eco-design Directive and the intention to increase the effectiveness of the current Eco-design framework for energy-related products, including the swift adoption and implementation the new Eco-design and Energy Labelling Working Plan 2020-2024 for individual product groups. This subprogramme should help accelerate the transition, reaping the benefits of the circular model in the EU and abroad. Moreover, in coherence with the new Action Plan, this subprogramme should address the enabling conditions to support circular economy transition, such as innovation and investment opportunities and enabling technologies. This subprogramme is particularly relevant for complex products and composite materials, listed among key product value chains, as indicated throughout the sections below.

To fulfil the objective in this subprogramme, the entire life cycle of complex products, including design for reuse, repair and remanufacturing were considered.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **A1.1. Analysis of composition and assembly technologies for different existing complex products**<br>This activity involves:<br>▪ Analysing the composition and review of assembly technologies for different existing complex products (e.g. WEEE, batteries, wood-based panels, multi-material paper packaging, end-of-life tyres and others) for each of their value chains.<br>TRL: Lab or in-house demonstration (4) --> TRL: Field pilot (6) | ▪ Research centres and universities (technical analysis)<br>▪ Producers (product design, manufacturing processes etc.) |
| **A1.2 Evaluation of secondary resources as raw materials for complex products**<br>This activity involves:<br>▪ Evaluating secondary resources as raw materials for complex products (as in activity A1.3 below) in terms of their performance in its value chain<br>TRL: Lab or in-house demonstration (4) --> TRL: Field pilot (6) | ▪ Research centres and universities (technical support)<br>▪ Companies for scaling up design and as end-users (testing) |
| **A1.3 Design of complex products for recycling and reuse**<br>This activity involves:<br>▪ Designing complex products that can be recycled and reused with performance evaluation (on criteria such as durability, technological results, environmental impact and imported emissions) with an iterative process.<br>TRL: Lab or in-house demonstration (4) --> TRL: Field pilot (6) | ▪ Research centres and universities (technical support)<br>▪ Companies for scaling up pilot plants design and running and as end-users (testing) |

| | |
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| **A1.4 Building and testing of pilot plants**<br>This activity involves:<br>▪ Building pilot plants for the production of complex products that are designed for recycling and reuse for its value chain.<br>TRL: Lab or in-house demonstration (4) --> TRL: Field pilot (6) | ▪ Local administrations working together with a coordinated approach (providing premises and specific authorisation)<br>▪ Civil society (social acceptance)<br>▪ Companies for buildings and running |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| A1.1 Analysis of composition and assembly technologies for different existing complex products<br>A1.2 Evaluation of secondary resources as raw materials for complex products | A1.3 Design of complex products for recycling and reuse<br>A1.4 Building and testing of pilot plants |

### *Subprogramme A2: Circular business model strategies for complex products*

**Rationale for the subprogramme**

This subprogramme is connected to the New EU Circular Economy Action Plan and its focus on eco-design for circular economy implementation. It contributes to accelerating the circular economy transition, reaping the benefits of the circular business models in the EU and abroad, working in strict connection with subprogramme A1 above. As mentioned in the CEAP, the European Commission will promote more circular business models by linking design issues to end-of-life treatment, considering rules on mandatory recycled content for certain materials of components, and improving recycling efficiency.

New circular economy business models should facilitate:

- interaction between institutions and firms and the diffusion of good circular economy practices, aimed at sustainable resource supply and synergies among enterprises,
- reduction of resource consumption in industrial sites and valorisation of residues, and
- improvement in stakeholder collaboration and capability in operating on the market, also creating public-private partnerships and communities for increasing local investments and developing the economy (e.g. with new value chains, firms and jobs).

In coherence with the new CEAP this subprogramme could foster the development of new circular business models including reuse, repair and collaborative models, recycling installations to treat waste domestically, urban mining, better quality of secondary raw materials and so on. Responding to the commitments of the European Green Deal, this subprogramme should also contribute to developing an industrial strategy for a clean and circular economy.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **A2.1 Downgrade materials analysis**<br>This activity involves:<br>▪ Analysing the materials needed for each sector and the standard and purity requested in relation to their application. The purpose is to facilitate the positioning of the market for recycled materials to fill this demand.<br>TRL: Field pilot (5) --> TRL: Field pilot (6) | ▪ Companies (providing needs per sector/value chain and for development)<br>▪ Research centres and universities (for technical support) |
| **A2.2 Circular business models development**<br>This activity involves:<br>▪ Developing circular economy business models along value chains (e.g. developing a regional pilot using a coordinated approach), aiming also to extend product life through reuse, repair and recycling (e.g. industrial symbiosis, sharing economy).<br>▪ Consideration of consumer needs and the relationship between business model design and behavioural change.<br>TRL: Lab or in-house demonstration (4) --> TRL: Field pilot (6) | ▪ Companies (for business models development)<br>▪ Local authorities (providing in- kind contribution for coordinated approach and local needs/resources info) |

| | |
|---|---|
| **A2.3 Testing of circular business models**<br><br>This activity involves:<br>▪ Testing circular business models in a real environment along the value chain (e.g. in a regional pilot using a coordinated approach), aiming also to extend product life through reuse, repair and recycling.<br>▪ Involving consumer groups in tests and aligning business model development with consumer needs.<br><br>TRL: Field pilot (6) --> TRL: Market introduction (8) | ▪ Companies (to conduct business model testing)<br>▪ Local authorities (providing in- kind contribution for coordinated approach)<br>▪ Consumer association for consumers involvement |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| A2.1 Downgrade materials analysis | A2.2 Circular business models development |
| | A2.3 Testing of circular business models |

## Objective B: To address toxic/hazardous substances to human and environmental health in the context of circular economy

### *Subprogramme B1: Circular design and technical development for human and environmental health*

**Rationale for the subprogramme**

This subprogramme was developed in connection with the current activities of the European Chemicals Agency (ECHA), European regulations on chemical substances, and strategies connected with the New Circular Economy Action Plan. This subprogramme contributes to the acceleration of circular economy transition, reaping the benefits of the circular model in the EU and abroad. It also contributes to meeting the needs of health and wellbeing of consumers. Indeed, the CEAP, selecting different value chains as priorities, underlines the need to improve product durability, reusability, upgradability and reparability, while also addressing the presence of hazardous chemicals in products and designing products that tackle the presence of hazardous chemicals.

Finally, Horizon Europe will support the development of indicators and data, novel materials and products, and methods to substitute and eliminate hazardous substances based on a "safe by design" approach. It will also support the development of circular business models and new production and recycling technologies, including the exploration of the potential of chemical recycling, keeping in mind the role of digital tools to achieve circular objectives. Furthermore, the Marie Curie Actions research programme is expected to support the development of skills, training and mobility of researchers in this area.

Moreover, in connection with the EU Industrial Strategy, this subprogramme activates the industrial sector and all value chains towards a model of sustainable and inclusive growth, ensuring efficient and clean resource cycles. Responding to the commitments of the European Green Deal, this subprogramme will likely create positive impacts at the socio-economic level, ensuring adequate investment opportunities to develop and deploy new technologies.

To fulfil the objective in this subprogramme, circular design for safety was considered as the main approach. This requires developing technologies for detecting and separating hazardous materials.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **B1.1 Improvement of existing technologies for detecting and separating hazardous materials**<br>This activity involves:<br>▪ Recognising existing technologies for detecting and separating hazardous materials from complex products.<br>▪ Improving existing technologies for detecting and separating hazardous materials from complex products.<br>▪ Scaling up existing technologies for detecting and separating hazardous materials from complex products.<br>TRL: Field pilot (5) --> TRL: Market introduction (7) | ▪ Research centres and universities (technical support)<br>▪ Companies (scaling up and testing)<br>▪ Local authorities (providing authorisation) |
| **B1.2 Development of new technologies for detecting and separating of hazardous materials**<br>This activity involves:<br>▪ Developing new technologies for detecting and separating hazardous materials. In particular flexible and modular pilot plants should be designed to be applied to different products.<br>TRL: Lab or in-house demonstration (3) --> TRL: Field pilot (5) | ▪ Research centres and universities (technical support) |

| | |
|---|---|
| **B1.3 Scaling-up of technologies for detecting and separating hazardous materials**<br><br>This activity involves:<br><br>▪ Scaling up new technologies for detecting and separating hazardous materials.<br><br>TRL: Field pilot (5) --> TRL: Market introduction (7) | ▪ Research centres and universities (technical support)<br><br>▪ Companies (scaling up and testing)<br><br>▪ Local authorities (providing authorisation) |
| **B1.4 Circular safety design**<br><br>This activity involves:<br><br>▪ Conducting circular design of materials and products without hazardous substances and with iterative processes, integrating ECHA feedback.<br><br>TRL: Lab or in-house demonstration (3) --> TRL: Field pilot (6) | ▪ Substances authorities (e.g. ECHA, on matters related to information requirements)<br><br>▪ Universities (technical support)<br><br>▪ Companies (scaling up and testing) |
| **B1.5 Traceability systems for communicating chemicals of concern in products**<br><br>This activity involves:<br><br>▪ Developing, consolidating and/or improving ecolabel systems related to chemicals of concern to streamline the many decentralised and scattered ecolabels that already exist on the market.<br><br>▪ Coordinating with manufacturers and supply chains to collect and standardise information, across various sectors and product types. The needs and participation of consumers and citizens should also be considered, in terms of the retail, use and end-of-life stages.<br><br>TRL: Field pilot (6) --> TRL: Scaling (9) (systems exist but at very small scale) | ▪ Experts in: environmental chemistry, digital platform/app developers, ecolabel experts, consumer behaviourists<br><br>▪ Industry groups including value chain actors<br><br>▪ Operators and participants of existing ecolabel systems for chemicals in products<br><br>▪ Policymakers – EU, national and municipal levels<br><br>▪ Consumers |
| **B1.6 Circular business models for human and environmental health**<br><br>This activity involves:<br><br>▪ Developing business models for complex products that are designed without hazardous materials<br><br>▪ Testing the business models in a real environment and identifying opportunities for market introduction and upscaling.<br><br>▪ Adopting a closely coordinated approach with key actors, namely industries, companies and value chain actors.<br><br>TRL: Lab or in-house demonstration (3) --> TRL: Market introduction (7) | ▪ Companies (main actors)<br><br>▪ Research centres and universities<br><br>▪ Consumer groups<br><br>▪ Local authorities (providing in-kind contribution for coordinated approach) |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| B1.1 Improvement of existing technologies for detecting and separating hazardous materials | B1.3 Scaling-up of technologies for detecting and separating hazardous materials |
| B1.2 Development of new technologies for detecting and separating of hazardous materials | B1.4 Circular safety design |
| | B1.5 Traceability systems for communicating chemicals of concern in products |
| | B1.6 Circular business models for human and environmental health |

## Objective C: To elaborate and stimulate the adoption of new policies, standard and protocols for governance resource management systems, fostering inter-stakeholder collaboration and integrated management in the entire value chain

### *Subprogramme C1: Traceability and management of raw materials to support governance and standardisation*

**Rationale for the subprogramme**

This subprogramme is the basis for the whole 'Closing the loop' joint programme and is connected to all activities. It focuses on the development of data systems and tools to support circularity and provide tools to industries to better manage their supply chains. In accordance with the new Circular Economy Action Plan, this subprogramme contributes to the development of the EU market for secondary raw materials as many businesses and public buyers are ready to switch to recycled materials. Moreover, the subprogramme helps to foster a well-functioning and integrated internal market for secondary raw materials to ensure that they are safe, competitively priced and reliable. Responding to the commitments of the European Green Deal, this subprogramme should create positive socioeconomic impacts to promote investment opportunities and develop and deploy new infrastructure. To fulfil the objective in this subprogram, the need for a European database of raw materials was considered.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **C1.1 Flow analysis of critical and non-critical raw materials**<br>This activity involves:<br>▪ Conducting flow analysis of critical and non-critical raw materials needed in relevant complex products, per European region and at the global level.<br>▪ This activity should start with the collection and homogenisation of existing documents.[16]<br>TRL: Field pilot (5)--> TRL: Scaling (9) | ▪ Companies (needs collection)<br>▪ Research centres and universities (technical support) |
| **C1.2 European database of raw materials building on suitable IT support**<br>This activity involves:<br>▪ Developing a European database of raw materials building on suitable IT support at the regional level, using a coordinated approach and technologies.<br>▪ Developing guidelines in order to promote the use of database and promote traceability of raw materials.<br>TRL: Field pilot (5) --> TRL: Scaling (9) | ▪ IT companies (IT support for IT instrument development) |

[16] Examples of this include:
- Raw materials scoreboard 2018
- Study on Data for a Raw Material System Analysis: Roadmap and Test of the Fully Operational MSA for Raw Materials
- Study on the review of the list of critical raw materials
- Material Flow Analysis of Aluminium, Copper, and Iron in the EU-28

| | |
|---|---|
| **C1.3 European database of raw materials at regional level**<br><br>This activity involves:<br>▪ Building a European database of raw materials at the regional level using a coordinated approach and technologies, building on existing systems (e.g. EU Raw Materials Information System (RMIS)).[17]<br><br>TRL: Lab or in-house demonstration (4) --> TRL: Field pilot (6) | ▪ Research centres and Universities (technical support)<br>▪ Companies (scaling up and testing)<br>▪ Local authorities (providing authorisation) |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| C1.1 Flow analysis of critical and non-critical raw materials<br><br>C1.2 European database of raw materials building on suitable IT support | C1.3 European database of raw materials at regional level |

[17] URL: https://rmis.jrc.ec.europa.eu/

## *Subprogramme C2: Promoting market viable solutions for circular economy*

**Rationale for the subprogramme**

The new EU Circular Economy Action Plan involves the introduction of requirements for recycled content in products, aiming to contribute to preventing a mismatch between supply and demand of secondary raw materials and to ensure the smooth expansion of the recycling sector in the EU. This subprogramme supports design for circularity and provides tools to industry for better managing their supply chains, contributing to developing the EU market for secondary raw materials as many businesses and public buyers are ready to switch to recycled materials. This subprogramme should overcome the lack of information regarding the presence or absence of substances of concern in products and waste, which often hampers their recycling and uptake. Moreover, it should contribute to fostering a well-functioning and integrated internal market for secondary raw materials to ensure that they are safe, competitively priced and reliable. Responding to the commitments of the European Green Deal, this subprogramme should create positive impact on the socioeconomic level ensuring adequate investment opportunities to develop and deploy new infrastructure.

To fulfil the objective in this subprogram, the need for a European industrial symbiosis platform was considered.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **C2.1 Materials and sectors analysis**<br>This activity involves:<br>a. Deep analysis material strategic for transition to Circular Economy at European level.<br>b. Downgrade materials analysis because of the results from part A. This activity includes the analysis of materials needed per sector and their standard/ requested purity grade in relation to the application. This could facilitate the position on the market of recycled materials.<br>TRL: Lab or in-house demonstration (4) --> TRL: Field pilot (6) | ▪ Companies (for needs info sharing)<br>▪ Authorities (for resources info sharing) |
| **C2.2 European industrial symbiosis platform (data)**<br>This activity involves:<br>▪ Feeding of European industrial symbiosis platform after the engagement and recruitment of companies.<br>▪ The industrial symbiosis platform has the objective to enable the transfer of resources (materials, energy products, water, services and expertise) and to offer other operational instruments (legal databases, LCA and eco-design tools, best practice databases, etc.) to small and medium enterprises (SMEs) and other local operators.<br>▪ Once registered, enterprises can provide their own information about the inputs and outputs they want to share with the users of the platform. They can also have the possibility to use all of the functions provided by the platform (queries, databases, industrial symbiosis matching), and look for cooperation in terms of industrial symbiosis potential.<br>TRL: Field pilot (5) --> TRL: Market introduction (7) | ▪ Companies (for sharing info)<br>▪ Research centres<br>▪ University (for industrial symbiosis model setting) |

| | |
|---|---|
| **C2.3 European industrial symbiosis platform (instrument)**<br>This activity involves:<br>▪ Building of the European industrial symbiosis platform.<br>TRL: Lab or in-house demonstration (4) --> TRL: Market introduction (8) | ▪ ICT companies |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| C2.1 Materials and sectors analysis | C2.2 European industrial symbiosis platform (data)<br>C2.3 European industrial symbiosis platform (instrument) |

### 3.3.1 Pilot Joint Call – Closing the Loop

**Rationale for this pilot joint call:** Too often, circular economy initiatives and projects focus only on one or two phases of the value chain, while an overall life cycle thinking extended to the entire value chain is mandatory to achieve the closure of the loop. In this pilot joint call, all the value chain phases are taken into consideration and the different typology of stakeholders are involved, in order to assure that all criticalities are faced and solved. An extra territorial approach is also foreseen in the projects under this call.

**How innovation is integrated:** This pilot joint call considers a specific value chain of interest (e.g. specific critical raw material such as phosphorous or rare earths, or a type of complex product such as batteries or electronic equipment). It takes into consideration the relevant existing initiatives and stakeholders to be involved, identifies the technological and non-technological gaps and implements R&I activities for the closure of the loop.

**EXAMPLE JOINT CALL 1:** ***DEVELOPMENT OF REPLICABLE AND SUSTAINABLE JOINT SOLUTIONS FOR CLOSING THE LOOP IN RAW MATERIALS SUPPLY AND INCREASING SECONDARY MARKETS IN EUROPE***

*This is an example of a joint call that can be created by programme owners under the Closing the Loop joint programme.*

**Topics covered:** Raw materials supply, secondary markets, recycling and reuse, downgrade material analysis, plastics, value chains, waste

**Description:**

The objective of this call is to develop replicable and sustainable joint solutions for closing raw material supply loops and increase European markets in raw materials. It contributes to the strategies and targets described above.

The projects funded in the call should demonstrate a sustainable replicable method to enhance secondary markets in Europe, both at technological and non-technological level, through closing the loop in raw materials supply. The project should contribute to the reinforcement of European manufacturing.

**The expected impacts of this call are:**

- Reduction of raw materials dispersion according to circular economy indicators
- Increase in the European internal market of raw materials according to circular economy indicators
- Decrease of raw materials import in Europe according to circular economy indicators
- Increase in job creation in raw materials according to circular economy indicators
- Decrease in the use of hazardous materials in European products according to circular economy indicators

**Desired actors involved:** This call is open for application to value chain public, private and civil actors, existing raw materials platforms especially those addressing nutrients and phosphorus issues and complex products alliances (e.g. European Battery Alliance).

Other key stakeholders that should be engaged are policy makers and certification bodies (for secondary raw materials).

**Locations/scale of application:** All EU/EEA countries. The project should be developed at macro level, demonstrating the replicability in the whole EU continent. Partners from outside Europe should be encouraged, especially the raw materials producers.

**TRL levels covered:** Aim to reach TRL 7 including a detailed pathway for reaching TRL 9 three years after the projects' end.

**This joint Call contributes to these SRIA objectives:**

- Closing the Loop Objective 1: To ensure that the manufacturing partnerships in Horizon Europe focus on key priorities in circular economy
- Closing the Loop Objective 2: To address toxic/hazardous substances to human and environmental health in the context of circular economy
- Closing the Loop Objective 3: To elaborate and stimulate the adoption of new policies, standard and protocols for governance resource management systems, fostering inter-stakeholder collaboration and integrated management in the entire value chain

## EXAMPLE PROJECT: *INTEGRATED SYSTEM OF TRACEABILITY AND MANAGEMENT OF RAW MATERIALS IN COMPLEX PRODUCTS*

*This is an example of a project under the above joint call: "Development of replicable and sustainable joint solutions for closing the loop in raw materials supply and increasing secondary markets in Europe".*

**Description:**

The project aims to build the first integrated system for tracking and monitoring the use of raw materials in Europe. In particular an overall raw materials platform will be built, leveraging on existing instruments (i.e. Joint Research Centre) and connected to product value chains through digital systems, aiming to trace the quantity, purity and use of raw materials in European products. The pilot will include the critical raw materials by connecting selected European regions and a preliminary study for other raw materials and regions.

The project will include the following steps:

- Collection of raw materials information through a detailed review of existing databases and data available on Eurostat/single statistic databases
- Development of a European database of raw materials building on suitable IT support
- Digital systems development for connecting products and European database including a digital tool for ICT recognition of components
- Flow analysis of critical and non-critical raw materials
- Downgrade analysis of material use, including their composition
- Pilot business cases on the reconversion of raw materials use for selected products/components
- Definition of a replication method

**Location(s) of project implementation:** EU-wide

**TRL levels:** The target TRL of this project is TRL 7

**This project will be implemented by a combination of the following groups:** Value chain actors, IT companies and software developers

**Basis of the project from the Circular Economy SRIA:**

Subprogrammes:

- Closing the Loop - Subprogramme C1: Traceability and management of raw materials to support governance and standardisation

Innovation fields:

- Plastics (2): Traceability and information in the plastic value chain
- Raw Materials (6): Efficiently aggregating valuable materials in waste collection
- Value Chains (2): Sustainable public procurement
- Waste (5): Innovations to accelerate recycling and secondary markets
- Waste (1): Setting up circular business models to extend product lifespan

**EXAMPLE JOINT CALL 2: *DEVELOPMENT OF REPLICABLE AND SUSTAINABLE JOINT SOLUTIONS FOR CLOSING THE LOOP IN STRATEGIC SECTOR (E.G. WEEE, CONSTRUCTION AND DEMOLITION, FOOD, TEXTILE) OR COMPLEX PRODUCTS (E.G. WEEE, BATTERIES)***

*This is an example of a joint call that can be created by programme owners under the Closing the Loop joint programme.*

**Topics covered:** Raw materials supply, secondary markets, recycling and reuse, downgrade material analysis, plastics, value chains, waste

**Description:**

The project should demonstrate a sustainable solution for closing the loop in strategic sectors (e.g. textile construction and demolition, food) or in complex products (e.g. WEEE, batteries) with the involvement of all the stakeholders that impact the value chain (producers, consumers, recyclers, policy makers, value chain closure enablers). Technical and non-technical aspects should be included. The project should contribute to reinforcing the European manufacturing industry in terms of competitiveness, sustainability and autonomy (in raw material supply and security).

**The expected impacts of this call are:**

- Raw material import reduction at European level according to circular economy indicators
- Increasing of job creation in products design, recycling according to circular economy indicators, value chain closure enablers, etc.
- European start-up dedicated to complex product design created according to circular economy indicators, new business models (pay for use, sharing economy), recycling plants

**Desired actors involved:** This call is open for application to value chain, public, private and civil actors, existing raw materials platforms especially those addressing nutrients and phosphorus issues and complex products alliances (e.g. Batteries Alliance). Other key stakeholders that should be engaged are policy makers and certification bodies (for secondary raw materials). Other key stakeholders that should be engaged are policy makers and certification bodies (for secondary raw materials).

**Locations/scale of application:** All EU/EEA countries. The project should be developed at macro level, demonstrating the replicability in the whole EU continent. Partners from outside Europe should be encouraged, especially the raw materials producers.

**TRL levels covered:** Aim to reach TRL 7 including a detailed pathway for reaching TRL 9 five years after the projects' end.

**This joint Call contributes to these SRIA objectives:**

- Closing the Loop Objective 1: To ensure that the manufacturing partnerships in Horizon Europe focus on key priorities in circular economy
- Closing the Loop Objective 2: To address toxic / hazardous substances to human and environmental health in the context of circular economy
- Closing the Loop Objective 3: To elaborate and stimulate the adoption of new policies, standard and protocols for governance resource management systems, fostering inter-stakeholder collaboration and integrated management in the entire value chain

## EXAMPLE PROJECT 2.1: *CLOSING THE LOOP IN EEE SECTOR*

*This is an example of a project under the above joint call: "Development of replicable and sustainable joint solutions for closing the loop in strategic sector".*

**Description:**

The project aims to build the first sustainable integrated solution for closing the loop in EEE sector. In particular, whole value chain of selected EEE products (i.e. printed circuit boards, photovoltaic panels, batteries) will be connected and closed. The project will be based on Life Cycle Thinking, following multidimensional, inclusive and multi-stakeholder approach and shall include actions on:

Sustainable supply
Design
Production
Use and reuse
Collection
} Circular business models
} LCA/LCC/Social LCA

The project will include the following steps:

- Composition and assembly technologies analysis of different existing complex products, including downgrade materials analysis
- Evaluation of secondary resources as raw materials for complex products
- Design of complex products for recycling and reuse
- Circular business models development
- Circular business models testing
- Pilot plants for recycling eco-designed complex products building and testing

**Location(s) of project implementation:** EU-wide

**TRL levels:** The target TRL of this project is TRL 7

**This project will be implemented by a combination of the following groups:** Value chain actors, IT companies and software developers

**Basis of the project from the Circular Economy SRIA:**

Subprogrammes:

- Closing the Loop - Subprogramme A1: Circular complex product design
  - A1.1 Analysis of composition and assembly technologies for different existing complex products
  - A1.2 Evaluation of secondary resources as raw materials for complex products
  - A1.3 Design of complex products for recycling and reuse
  - A1.4 Building and testing of pilot plants
- Closing the loop - Subprogramme A2: Circular business model strategies for complex products
  - A2.2 Circular business models development
- Closing the loop - Subprogramme B1: Circular design and technical development for human and environmental health

## EXAMPLE PROJECT 2.2: *CLOSING THE LOOP IN TEXTILE SECTOR*

*This is an example of a project under the above joint call: "Development of replicable and sustainable joint solutions for closing the loop in strategic sector".*

**Description:**

The project aims to develop an integrated pilot in the textile sector, reinforcing the European sustainable textile value chain. The project aims to implement a closed loop starting from the design of innovative and sustainable textile products that can be easily recycled (i.e. devices for personal health protection). Also, the production process will be designed to avoid the use of hazardous substances (according to the REACH regulation and promoting recyclability). The entire value chain shall be taken into consideration promoting market uptake, collection, reuse and recycling through the traceability of products, quality and circularity labelling/certification. Pilot plants for cradle to cradle recycling will be developed and implemented, to test the solution. The plant will be built in a flexible way in order to be applied to different products and replicate the method in different European regions. Dedicated circular business models will also be developed.

The project will include the following steps:

- Composition and assembly technologies analysis of innovative textile products, including downgrade materials analysis
- Evaluation of secondary resources as raw materials for innovative textile products
- Design of innovative textile products for recycling and reuse
- Circular business models development
- Circular business models testing
- Traceability and collection schemes
- Quality and circular labelling/certification
- Pilot plants for recycling eco-designed innovative textile products building and testing

**Location(s) of project implementation:** EU-wide

**TRL levels:** The target TRL of this project is TRL 7

**This project will be implemented by a combination of the following groups:** Value chain actors, IT companies and software developers. Also, fashion houses shall be involved to promote the use of circular textiles.

**Basis of the project from the Circular Economy SRIA:**

Subprogrammes:

- Closing the Loop - Subprogramme A1: Circular complex product design
  - A1.1 Analysis of composition and assembly technologies for different existing complex products
  - A1.2 Evaluation of secondary resources as raw materials for complex products
  - A1.3 Design of complex products for recycling and reuse
  - A1.4 Building and testing of pilot plants
- Closing the Loop - Subprogramme A2: Circular business model strategies for complex products
  - A2.2 Circular business models development
- Closing the Loop - Subprogramme B1: Circular design and technical development for human and environmental health

## 3.4 RESOURCE EFFICIENCY ON TERRITORY AND SEA

This joint programme focuses on the application of circular economy to the complex relationships between mainland human activities and open waters, chiefly represented by the technosphere environment of harbours. Priority is given to actions that promote transition to the circular economy in the management of small and big ports, fostering sustainable and circular innovations in the major productive sectors occurring in the ports and in the main activities and businesses linked to its economic life.

This joint programme is in line with the emerging Blue Economy principles and the Blue Growth perspective: the main topics addressed include sustainable tourism, integrated and circular waste and water management, climate change impacts including sea level rise and mitigation measures.

Managing this complex transition to a circular and sustainable anthropic connection between territory and sea should be driven by an integrated approach and a holistic view in order to create a feasible model for economic capital creation and natural capital safeguard. Based on this, the goal of this joint programme is to enable circular economy transition in ports and marine systems.

The specific objectives of this joint programme are:

1. To design and promote sustainable maritime transport, and
2. To promote efficient resource use in ports and coastal areas with a long-term perspective.

The innovations covered in this joint programme can create positive impact in the upscaled recovery and commercialisation of seafood by-products, integrated waste and water management, circular water vessel production, industrial symbiosis between cities, manufacturing and ports, and sustainable tourism and logistics. Such innovations can also create new business models and jobs.

The expected impacts of this joint programme include:

- Improved collaboration and synergies on sustainable development and circular economy transition between ports and coastal cities;
- Reduced energy and material consumption in marine industries including shipping, tourism and fisheries; and
- Reduced air and water pollution at ports and oceans leading to decreased negative environmental and human health impacts.

## Objective A: To design and promote sustainable maritime transport

### *Subprogramme A1: Transitioning to a circular and sustainable shipping industry*

**Rationale for the subprogramme**

This subprogramme is dealing with the transition to more sustainable shipping sector through the cold ironing[18] of the port areas and the implementation of a circular production system in the shipping sector aimed at reducing resource use and promoting recycling and reuse. These goals align with the Bluemed SRIA's[19] sections on technology enablers and in line with the measures in the International Maritime Organisation (IMO) strategy on the reduction of GHG emissions from ships and the shipping sector[20].

To fulfil the objective in this subprogram, the transition of the shipping industry towards circular economy in the area of maritime transport was considered. This requires measures such as scaling up electric solutions in the shipping and boat industry, using eco-design approaches for the shipping and boat industry, designing reverse logistic for dismissed boat, introducing the extended producer's responsibility in the legislation for the ship industry sector, developing innovative recyclable composite materials and cold ironing of the port areas.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **A1.1 Development of eco-design approaches for the watercraft production industry**<br>This activity involves:<br>▪ Implementing eco-design approaches in the watercraft design and production industry (including ships and boats).<br>▪ Designing and implementing solutions for the recycling and reuse of vessels to enable circular production models, including the reverse logistics systems for dismissed vessels.<br>TRL: Field pilot (6) --> TRL: Scaling (9) (Approaches and methodologies well developed, but rarely applied to the maritime sector) | ▪ Product designers<br>▪ Watercraft production companies<br>▪ Research centres<br>▪ Logistic experts<br>▪ Waste management companies<br>▪ Port authorities |
| **A1.2 Development of solutions for electric vessels in maritime transport and upscaling of cold ironing at port areas**<br>This activity involves:<br>▪ Designing, testing, developing and commercialising electric boats and ships and adapt port areas to provide cold ironing to electric vessels while hosting them at ports.<br>▪ Addressing the problem of high electricity demand by cruise ships by improving the design and implementation efficiency of electricity systems at ports.<br>TRL: Field pilot (6) --> TRL: Market introduction (7)/(8) to Scaling (9) (systems exist but at very small scale, therefore focus should be on scaling up) | ▪ Port cities (municipalities)<br>▪ Watercraft production companies<br>▪ Port authorities<br>▪ Research centres<br>▪ Batteries developers and producers<br>▪ Maritime companies<br>▪ Cruise companies |

[18] Cold ironing refers to the provision of shoreside electrical power to ships at berth while its engines are shut off, to maintain the functioning of emergency equipment, refrigeration and cooling/heating, etc.

[19] Based on the updated version of the Bluemed SRIA from 2018 which can be found here: http://www.bluemed- initiative.eu/wp-content/uploads/2018/12/BLUEMED-SRIA_Update_2018.pdf.

[20] The IMO strategy document can be found here: https://unctad.org/meetings/en/Contribution/dtltlbts- MyEM6thd04_IMO_en.pdf.

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|---|---|
| **A1.3 Development and market upscaling of innovative recyclable composite materials and 3D printing in the watercraft industry**<br><br>This activity involves:<br><br>▪ Designing, testing, developing and commercialising recyclable and sustainable composite materials, and fostering the introduction of 3D printing in the watercraft production industry.<br><br>TRL : Lab of in-house demonstration (3) --> TRL: Market introduction (7)/(8) (Prototypes of materials exist in the maritime sector, but not market solutions. Market solutions are available in the aviation sector) | ▪ Designers<br>▪ Watercraft production companies<br>▪ Research centres<br>▪ 3D printing companies |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| A1.1 Development of eco-design approaches for the watercraft production industry | A1.2 Development of solutions for electric vessels in maritime transport and upscaling of cold ironing at port areas<br><br>A1.3 Development and market upscaling of innovative recyclable composite materials and 3D printing in the watercraft industry |

## Objective B: Promoting efficient resource use in ports and coastal areas with a long-term perspective

### *Subprogramme B1: Transitioning to integrated resource management approaches working at the territorial level with a holistic and circular perspective*

**Rationale for the subprogramme**

This subprogramme focuses on transitioning to integrated resource management at the territorial level with a holistic and circular perspective. These goals are already present among the knowledge enablers and economic enablers of the Bluemed SRIA[21] as well as the Strategic Research and Innovation Agenda 2015-2020 of JPI Oceans - the Healthy and Productive Seas & Oceans Intergovernmental Platform[22].

To fulfil the objective in this subprogram, a holistic perspective on circular resource management at port areas was considered. This requires measures such as introducing more efficient resource management in ports and coastal areas, reducing environmental and social impact due to the port activities, introducing rehabilitation of neglected areas in the port areas, improving the urban connection of the port areas with the urban areas and citizens usability of the port areas. There is also a need of evaluation in the medium-long term of the effect of climate change on sea level and implementation of mitigation and adaptation solution to climate change effect to the sea level.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **B1.1 Design and implementation of industrial symbiosis platforms for discards and waste valorisation at ports (in connection with coastal cities)**<br>This activity involves:<br>▪ Fostering the diffusion of online platforms for industrial symbiosis at territorial level (i.e. coastal cities and ports) for the valorisation of resources, waste and discards as secondary materials or innovative products.<br>▪ Nature-based solutions to be used in re-naturalisation and climate change adaptation actions at port and coastal cities.<br>TRL: Field pilot (6) --> TRL: Market introduction (7)/(8) (Platforms exist but they are still a niche, so focus should be on scaling up) | ▪ Circular economy experts<br>▪ Research centres<br>▪ Companies of the blue economy<br>▪ Local authorities<br>▪ Port authorities<br>▪ Platform developers |
| **B1.2 Calculation models to design (mainly nature-based) climate change adaptation actions in ports and coastal cities**<br>This activity involves:<br>▪ Modelling sea level rise calculations to design the appropriate adaptation solutions for coastal cities and their port areas. A focus should be placed on nature-based solutions.<br>▪ Developing nature-based solutions aimed at the re-naturalisation of port areas, seas and coastal cities. Such solutions should also use secondary resources as much as possible. Connection can be made with Activity B1.1 of this subprogramme. | ▪ Blue economy companies<br>▪ Construction companies<br>▪ Research centres<br>▪ Local authorities<br>▪ Port authorities<br>▪ Nature based solution development companies |

[21] Available here: http://www.bluemed-initiative.eu/wp-content/uploads/2018/12/BLUEMED- SRIA_Update_2018.pdf.

[22] More information on the JPI Oceans SRIA can be found here: http://jpi-oceans.eu/news-events/news/jpi- oceans-sria-now-available.

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|---|---|
| TRL: Field pilot (6) --> TRL: Market introduction (7)/(8) (Models exist but not widely disseminated, and they should be improved in terms of spatial resolution and precision) | ▪ Climate change experts |
| **B1.3 Material flow analysis with a life cycle perspective at ports and coastal cities**<br>This activity involves:<br>▪ Developing and implementing efficient, integrated and circular resource management systems at ports and coastal cities using the Material Flow Analysis approach and with a lifecycle perspective, aimed at reducing raw material consumption, waste production and social and environmental impacts.<br>▪ The lifecycle perspective applied includes both lifecycle analysis and strategic lifecycle analysis.<br>TRL: Field pilot (6) --> TRL: Market introduction (7)/(8) (Approaches and methodologies exist but they are not so diffused at ports and coastal cities and in the blue economy sector) | ▪ Strategic lifecycle analysis experts<br>▪ Circular economy experts<br>▪ Research centres<br>▪ Companies of the blue economy<br>▪ Local authorities<br>▪ Port authorities |
| **B1.4 Innovation hubs in to foster circular economy in port areas and engagement with coastal cities**<br>This activity involves:<br>▪ Creating innovation hubs for blue economy stakeholders to interact and foster innovation, involve citizens and integrate port management into urban management. The potential for tourism development should be considered.<br>▪ Considering the rehabilitation of unused and neglected port buildings to become physical spaces for hosting the innovation hubs.<br>▪ Promoting the creation of protection areas which can play a role in safeguarding biodiversity and minimising long-term environmental impacts.<br>TRL: Field pilot (6) --> TRL: Market introduction (7)/(8) (Approaches and methodologies exist but they are not so diffused at ports and coastal cities and in the blue economy sector) | ▪ Blue economy companies<br>▪ Construction companies<br>▪ Innovation/research centres<br>▪ Local authorities<br>▪ Port authorities<br>▪ Architecture firms |
| **B1.5 Circular and sustainable tourism certification schemes**<br>This activity involves:<br>▪ Implementing circular economy and sustainable tourism certification schemes to foster more efficient and circular use of resources and exploit other actions aimed at a circular resource management in the tourism industry.<br>TRL: Lab or in-house demonstration (4) --> TRL: Market introduction (7)/(8) (Some solutions are already present on the market, but the sector needs to be developed overall) | ▪ Blue economy companies<br>▪ Tourism sector<br>▪ Research centres<br>▪ Hotels |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| B1.1 Design and implementation of industrial symbiosis platforms for discards and waste valorisation at ports (in connection with coastal cities) | B1.3 Material flow analysis with a life cycle perspective at ports and coastal cities |
| B1.2 Calculation models to design (mainly nature-based) climate change adaptation actions in ports and coastal cities | B1.4 Innovation hubs in to foster circular economy in port areas and engagement with coastal cities |
| | B1.5 Circular and sustainable tourism certification schemes |

### *Subprogramme B2: Transitioning to a sustainable fishing and circular aquaculture sector*

**Rationale for the subprogramme**

This subprogramme is the transition to a circular, sustainable and respectful of the biodiversity fishing and aquaculture sectors. These goals are already present among the Knowledge enablers and among the Economy enablers of the Bluemed SRIA in its updated version of 2018[23] and among the Strategic Areas of the Strategic Research and Innovation Agenda 2015-2020 of the JPI Oceans - the Healthy and Productive Seas & Oceans Intergovernmental Platform[24].

To fulfil the objective in this subprogram, the role the fishing and aquaculture was considered. This requires measures such as increasing the market share of market neglected fish species, reducing waste and introducing more efficient resource management of the fish transformation industry, fostering traditional fisheries processes and local fish species, implementing more sustainable aquaculture processes and introducing fish stock conservation.

**Subprogramme activities - R&I Actions**

List of activities of this subprogramme and their corresponding TRL levels (current TRL level and the desired/ targeted TRL level at the end of the activity):

| Activity name and description | Actors involved |
|---|---|
| **B2.1 Valorisation of fish species with commercialisation and sustainable extraction potential**<br>This activity involves:<br>▪ Valorising fish species with the potential for commercialisation and enough stock for sustainable extraction but are otherwise overlooked on the market. This can be accomplished by market promotion focused on the health and environmental sustainability features of such species.<br>▪ Valorising the nutritional, organoleptic and environmental (sustainable and traditional fishing processes) characteristics of the fish species through the appropriate labelling for consumers and tourists.<br>TRL: Field pilot (6) --> TRL: Market introduction (7)/(8) (Characterisation analysis and labelling already exist, but not aimed at reaching the goal described) | ▪ Fishing companies<br>▪ Communication companies<br>▪ Fishing associations<br>▪ Restaurants<br>▪ Characterisation labs<br>▪ Labelling programme developers<br>▪ Touristic companies<br>▪ Research centres |
| **B2.2 Valorisation of seafood by-products and promoting industrial symbiosis in the fisheries sector**<br>This activity involves:<br>▪ Valorising the discards and by-products of fish and promoting industrial symbiosis to shift the fisheries and seafood processing industry towards circular economy.<br>▪ Focusing on the valorisation of secondary materials to generate value-added products (e.g. in the pharmaceutical, nutraceutical, energy or animal feed industries).<br>▪ Using resource mapping at the territorial level and leveraging on industrial symbiosis e-platforms to conduct the valorisation.<br>TRL: Field pilot (5) --> TRL: Market introduction (7)/(8) (Some valorisation experience in the sector exist, but in general there is no implementation of the circular economy model in the sector) | ▪ Seafood processing companies<br>▪ Circular economy experts<br>▪ Characterisation labs (Laboratories dealing with characterisation of products or discards)<br>▪ Research centres<br>▪ Local authorities<br>▪ Port authorities<br>▪ Other companies from the seafood sector, able to valorise their discards |

[23] Accessible here: http://www.bluemed-initiative.eu/wp-content/uploads/2018/12/BLUEMED- SRIA_Update_2018.pdf
[24] Accessible here: http://jpi-oceans.eu/news-events/news/jpi-oceans-sria-now-available

| | |
|---|---|
| **B2.3 Implementation of sustainable multitrophic aquaculture processes in the appropriate marine areas**<br><br>This activity involves:<br>▪ Implementing sustainable multitrophic aquaculture processes aimed at reducing marine pollution and supporting fish stock conservation.<br>▪ Developing and using marine dynamics models to account for climate change effects over a medium to long term perspective, to define optimal areas for aquaculture implementation.<br>▪ Labelling sustainable seafood products from aquaculture based on their nutritional, health and sustainability features.<br><br>TRL: Field pilot (6) --> TRL: Market introduction (7)/(8) (Some multitrophic plants exist, but in general the sector is implementing traditional processes that are pollution intensive) | ▪ Aquaculture companies<br>▪ Restaurants<br>▪ Characterisation labs<br>▪ Labelling programme developers<br>▪ Research centres (biologists)<br>▪ Environmental experts<br>▪ Climate change modelists |

**Subprogramme timeline**

| Period & Activities | |
|---|---|
| **Year 1-4** | **Year 5-10** |
| B2.1 Valorisation of fish species with commercialisation and sustainable extraction potential | B2.2 Valorisation of seafood by-products and promoting industrial symbiosis in the fisheries sector<br><br>B2.3 Implementation of sustainable multitrophic aquaculture processes in the appropriate marine areas |

### 3.4.1 Pilot Joint Call – Resource Efficiency on Territory and Sea

**Rationale for this pilot joint call:** For the resource efficiency on Territory and Sea joint programme, the existing initiatives and projects dedicated to territory and sea are mainly focusing either on natural resources management or to specific fragments of the blue economy. However, an overall socio-economic and environmental approach needs to be improved in order to assure a circular economy approach in the management of territory and also to connect blue and circular economy in an organised way. Specific attention should be given to the complex relationships between mainland human activities and open waters, and specifically to ports, which consist of the characteristics of both urban and industrial areas and represent the main connection between land and sea.

The existing initiatives and projects on sustainable ports only focus on energy efficiency and logistics, excluding all the aspects related to material, waste and water efficiency management and the connections between land and sea, and natural and anthropic resource management. There is a strong need to enlarge the initiatives towards an integrated approach and a holistic view in order to create a feasible model for economic capital creation and natural capital safeguard. Given the typology of project a territorial approach is foreseen. In addition, it is essential that a common and interlinked approach is implemented with regards to blue economy in connection to circular economy.

**How innovation is integrated:** The management of small and big ports is designed and implemented in connection to coastal zones including actions on upscaled recovery and commercialisation of seafood by-products, integrated waste and water management, circular water vessel production, industrial symbiosis between urban and port areas, manufacturing and ports, and sustainable tourism and logistics. Such innovations can also create new business models and jobs.

**EXAMPLE JOINT CALL: *SUSTAINABLE AND CIRCULAR PORTS AND COASTAL TERRITORIES***

*This is an example of a joint call that can be created by programme owners under the Circular Cities joint programme.*

**Topics covered:** marine industries including shipping, tourism and fisheries; raw material, biomass and biotechnologies, waste, water efficient use and management; industrial symbiosis

**Description:**

The objective of this call is to develop replicable, holistic and integrated solutions to promote efficient and circular resource management in port areas and sustainable and resilient development in coastal territories.

The projects funded should demonstrate a sustainable and replicable approach to manage the port and coastal areas with an integrated and circular approach aimed at exploiting resources efficiently, reducing the pressure on the coastal and marine environment and valorising waste and discards keeping value on the territories through eco-innovative solutions.

**The expected impacts of this call are:**

- Improved collaboration and synergies on sustainable development and circular economy transition between ports and coastal cities;
- Reduced energy and material consumption in marine industries including shipping, tourism and fisheries; and
- Reduced air and water pollution at ports and oceans leading to decreased negative environmental and human health impacts.

**Desired actors involved:** This call is open for application to product designers, watercraft production companies, research centres, logistic experts, waste and water management companies, port authorities, maritime and cruise companies, tourism companies, fishing, aquaculture and fisheries companies.

Other key stakeholders that should be engaged are policy makers, climate change experts and civil society.

**Locations/scale of application:** All EU/EEA countries. The project should be developed at macro level, demonstrating the replicability in the whole EU continent. The project could be applied not only to sea ports, but also to river and lake ports. Partners from outside Europe should be encouraged, especially from the European Neighbourhood and Partnership Instrument (ENPI) side.

**TRL levels covered:** Aim to reach TRL 7 including a detailed pathway for reaching TRL 9 three years after the projects' end.

**This joint Call contributes to these SRIA objectives:**

- Territory and Sea Objective A: To design and promote sustainable maritime transport
- Territory and Sea Objective B: To promote efficient resource use in ports and coastal areas with a long-term perspective

## EXAMPLE PROJECT: *RESILIENT AND SUSTAINABLE COASTAL TERRITORIES*

*This is an example of a project under the above joint call: "Sustainable and circular ports and coastal territories".*

**Description:**

The project aims to develop a holistic and sustainable territorial management system in coastal areas by implementing circular economy principles to achieve a fruitful coexistence between humans and nature in coastal territories.

To fulfil the objective, the following measures shall be implemented: designing nature based solutions aimed at mitigating the effects of sea level rise caused by climate change on human activities and natural coastal areas; fostering small and traditional fisheries also through touristic promotion of their activities and products in order to preserve biodiversity and keep value on the territory; a responsible and sustainable tourism through the certification of sustainable and circular touristic activities; introducing an integrated, efficient and circular waste and wastewater management system with the ability to valorise waste in resources while also considering fluctuations due to touristic dynamics.

The project shall include the following activities:

- Designing nature-based solutions for the mitigation of climate change effect and re-naturalisation of coastal areas;
- Defining and implementing sustainability and circularity certification schemes aimed at valorising neglected fish species and discards from fish transformation in order to promote small and traditional fisheries. The use of recyclable fishing nets and fish transformation valorisation in nutraceutic or pharmaceutic sectors are just two examples;
- Defining and implementing sustainability and circularity certification schemes (local) aimed at promoting circular touristic activities in the territories (i.e. hospitality sector, entertainment sector, etc...);
- Designing and implementing an integrated, efficient and circular waste and wastewater management system able to valorise waste into resources, connected with the previous activities listed.

**Location(s) of project implementation:** EU-wide (front-sea areas, lake and river areas) and Mediterranean Sea

**TRL levels:** The target TRL of this project is TRL 7

**This project will be implemented by a combination of the following groups:** Research centres, waste and water management companies, port authorities, touristic companies, fishing companies, municipalities

**Basis of the project from the Circular Economy SRIA:**

Subprogrammes:

- Subprogramme B1: Transitioning to integrated resource management approaches working at the territorial level with a holistic and circular perspective
- Subprogramme B2: Transitioning to a sustainable fishing and circular aquaculture sector

# 4 Research and Innovation Priority Areas

# 4. Research and Innovation Priority Areas (Innovation Fields)

The SRIA is primarily about research and innovation. It is also aimed at supporting programme owners in strategically orienting research funding, and as such it needs to target areas of market and societal interest. The innovation fields (IFs) are areas of research and innovation that are oriented towards functionality and usage value. They are formulated as to address clear requirements and encompass technical and scientific solutions.

This section describes the priority innovation fields which are the basis of the four joint programmes. The innovation fields were identified by programme owners, policymakers and other key EU stakeholders. This section lists the priority areas of research and innovation for the four societal challenge areas (urban areas, industrial systems, value chains and territory and sea) and eight themes (biomass and biotechnologies, chemicals, construction and demolition, food, plastic, raw materials, waste and water).

## 4.1 Societal Challenge Areas

### 4.1.1 Urban Areas

The Urban Areas challenge focuses on increasing circular flows of materials and energy in cities in order to improve consumption efficiencies and minimise waste, thereby reducing negative sustainability impacts. The engagement of citizens is key. It refers to the sustainability challenges related to the management and development of areas where humans live in concentration. It commonly includes housing, urban transport, sanitation, utilities, land use and communication, and covers urban and peri-urban areas. Examples at different geospatial scales are: micro - individual households and buildings; meso - individual city level; and macro - interactions between cities, agglomerations and sister cities (with social/political/cultural ties or partnerships).

The Urban Areas challenge is the basis of the Circular Cities joint programme in this SRIA.

***OBJECTIVES***

The objectives of the Urban Areas challenge are:

| | |
|---|---|
| **Objective 1.** | Developing services to fulfil citizen needs and increase citizen engagement in waste management, recycling and second-hand markets in cities. |
| **Objective 2.** | To improve resource management (water and soils) in urban and suburban areas, and areas with industrial agriculture |

***INNOVATION FIELDS***

| | Innovation Field | Corresponding objective(s) |
|---|---|---|
| 1 | **Citizen involvement for circular and sharing economy**<br>Understanding how citizens relate to circular and sharing economy and building knowledge and methods for this | Objective 1 |
| 2 | **Circular systems for used products**<br>Systems for sharing, repair and circulation of used products | Objective 1 |
| 3 | **Green public procurement programmes**<br>Identifying programmes for second-hand markets in public procurement | Objective 1 |
| 4 | **Advanced water treatment systems to promote circularity**<br>Upgrading water treatment systems to increase recycling and reuse as well including risk analysis | Objective 2 |
| 5 | **Advanced waste management systems for circularity**<br>New and improved waste systems for shifting towards circular collection systems | Objective 2 |

### 4.1.2 Industrial Systems

The Industrial Systems challenge addresses the efficient use of resources and the sustainable production through the implementation of innovative technologies and tools at the level of individual factories, industrial areas or industrial networks.

The actions concern innovation in product design, production processes, efficient use and management of resources, reduction of emissions and waste, valorisation of process waste, collaborative exchanges between different industries and cross-sector collaboration (for example through industrial symbiosis), the sustainable and circular management of industrial areas, the redevelopment of industrial areas and the conversion of existing factories to the circular economy.

The Industrial Systems challenge is the basis of the Circular Industries joint programme in this SRIA.

***OBJECTIVES***

The approach is based on innovative integrated solutions to be implemented in factories, industrial areas and production sectors (agro-industry, metallurgy, textiles, etc.), in order to address the efficient use of resources in industry, the sustainable production and the closure of cycles.

The objectives of the challenge are:

| | |
|---|---|
| **Objective 1.** | To develop new technologies, quality standards and analytic methods for new materials production and resource and waste characterisation |
| **Objective 2.** | To enable industrial symbiosis networks and foster digitalisation to master the complexity of products, processes and systems |

| | |
|---|---|
| **Objective 3.** | To raise awareness of industrial ecology by promoting new/ better design and use of products and better re-use of materials already in circulation |
| **Objective 4.** | To reduce the carbon emissions of the 100 most polluting companies |
| **Objective 5.** | To develop new process and digital (twin) technologies for reducing losses from the CE system |

***INNOVATION FIELDS***

| | Innovation Field | Corresponding objective(s) |
|---|---|---|
| 1 | **High value manufacturing integrating eco-design**<br>High value manufacturing integrating eco-design in the process, focusing on additive manufacturing instead of subtractive manufacturing to boost material efficiency. | Objective 2 and 3 |
| 2 | **Digitalisation and circular economy research and projects**<br>Development of sectorial and cross-sector knowledge and innovation networks which address circularity capacity, knowledge and implementation gaps in different regions of Europe Involving SME's in digitalisation and circular economy research and projects | Objective 1 and 2 |
| 3 | **Biorefineries support**<br>Supporting biorefineries in chemicals and plastics production and for biofuel or energy production | Objective 1 and 4 |
| 4 | **Optimisation of metallurgical processes**<br>To develop new technologies for the optimization of metallurgical processes in the extraction of CRM from primary and secondary raw material feeds by reducing effluents | Objective 1 and 5 |

### 4.1.3 Value Chains

The challenge 'Value chain' covers the main topics for closing the loop of specific materials (e.g. Critical Raw Materials or others), products (e.g. plastic packaging, WEEE, tyres, etc.) and in specific supply chains (such as buildings, agro-industry, textile, etc.). Within this challenge all value chain phases need to be taken into consideration: design, material supply and production, consumption and distribution and end-of-life as new production of materials. This type of challenge has itself a wide territorial extension that typically applies from national to global scale (depending on the geographical area of supply for primary resources).

The Value Chains challenge is the basis of the Closing the Loop joint programme in this SRIA.

***OBJECTIVES***

The goal is the implementation of synergic actions involving all the actors of the value chain (designer, producer, distributor, user, end of life manager, recycler) in order to identify barriers and remove bottlenecks and broken rings hindering the closure of loop and implement a sustainable system for all the actors involved.

The objectives of the challenge are:

| | |
|---|---|
| **Objective 1.** | To ensure that the manufacturing partnerships in Horizon Europe focus on key priorities in circular economy |
| **Objective 2.** | To address substances of concern to human and environmental health in the context of circular economy |
| **Objective 3.** | To elaborate and stimulate the adoption of new policies and protocols for governance resource management systems, fostering inter-stakeholder collaboration and integrated management in the entire value chain, also through reverse logistics, and promoting participation among young people, for boosting knowledge about secondary materials |

***INNOVATION FIELDS***

| | Innovation Field | Corresponding objective(s) |
|---|---|---|
| 1 | **Product lifetime extension**<br>To extend product lifetimes and develop innovative business models including aspects such as industrial symbiosis in order to realise an effective closure of the loop within entire value chains | Objective 1 |
| 2 | **Sustainable public procurement**<br>Develop criteria for circularity and establish a uniform method for governments in sustainable public procurement | Objective 3 |
| 3 | **Sustainable sourcing**<br>To promote sustainable sourcing following Circular Economy principles | Objective 2 |

### 4.1.4 Territory and Sea

Territory & Sea is the challenge dealing with the complex relationships between mainland human activities and the open water, chiefly represented by the technosphere environment of harbours. The goal is to set up a line of actions aimed to a suitable transition to the Circular Economy in the small and big ports management, by fostering sustainable and circular innovations in the main productive sectors occurring in the ports and in the main activities and businesses linked to its economic life.

In line with the emerging Blue Economy principles and the Blue Growth perspective, the main addressed topics to be tackled will be - among others - marine litter, sustainable tourism, integrated waste and water management, but also the sea level increasing due to the climate change effects and the solutions for its mitigation. Innovation could lead, for example, to the fishing traceability and valorisation of the fish supply chain residues in new products, to the integrated waste and water management, to an industrial symbiosis platform implementation, to sustainable logistics in tourists and goods management and to new jobs opportunity and businesses.

Managing this complex transition to a circular and sustainable anthropic connection between territory and sea should be driven by an integrated approach and a holistic view in order to create a feasible model for economic capital creation and natural capital safeguard.

The Territory and Sea challenge is the basis of the Resource Efficiency on Territory and Sea joint programme in this SRIA.

***OBJECTIVES***

The approach is based on innovative integrated solutions to be implemented in factories, industrial areas and production sectors (agro-industry, metallurgy, textiles, etc.), in order to address the efficient use of resources in industry, the sustainable production and the closure of cycles.

The objectives of the challenge are:

| | |
|---|---|
| **Objective 1.** | To design and promote sustainable maritime transport |
| **Objective 2.** | To promote efficient resource use in port areas and surroundings with a long-term perspective |

***INNOVATION FIELDS***

| | Innovation Field | Corresponding objective(s) |
|---|---|---|
| 1 | **Remanufacturing for the shipping industry**<br>Transition to a circular shipping industry through product, process and system innovations (e.g. use of recyclable composite fibres in the ship production; electrification) | Objective 1 |
| 2 | **Integrated resource management approaches working at the territorial level with a holistic and circular perspective**<br>Implementation of circular, integrated and holistic resource management systems at the territorial level through eco-innovation and social actions at the product, process, system, value chain and sector levels, with a long-term perspective for transition to a circular economy able to adapt to and mitigate the climate change effects | Objective 2 |
| 3 | **Optimal fishing and aquaculture strategies**<br>Circular resources management in the aquaculture and fisheries sectors through optimal resource use and the valorisation of by-products, discards and wastes with industrial symbiosis implementation | Objective 2 |

## 4.2 Themes

### 4.2.1 Biomass and biotechnologies

Biomass and biotechnologies have an important role in circular economy and are in the centre of a circular bioeconomy. Although biomass is renewable, the sustainable supply, production and consumption of biomass should not be taken for granted. When targeting a more bio-based circular economy and more circular bioeconomy, the focus should be on resource and energy efficiency and the cascading use of biomass and biotechnologies, prioritising the production of added value chemicals and biobased materials, and finally biofuels. Energy production must be considered the last choice for closing the loop. Integration of cascading and circular principles along the biomass and biotechnologies value chain is required in order to transform the use of biomass and biotechnologies to be more sustainable.

The biomass and biotechnologies theme contribute to sustainable supply and its cascading use for sustainable and resource efficient production and consumption of renewable chemicals, materials, fuels and energy in the EU.

***OBJECTIVES***

The objectives of the Biomass and biotechnologies theme are:

| | |
|---|---|
| **Objective 1.** | To ensure secure and sustainable biomass feedstock supply and cascading use |
| **Objective 2.** | To optimise efficient processing for integrated and circular biorefineries |
| **Objective 3.** | To develop innovative biobased products and materials for a more biobased circular economy and more circular bioeconomy |

***INNOVATION FIELDS***

| | Innovation Field | Corresponding objective(s) |
|---|---|---|
| 1 | **Sustainable management of biomass feedstocks from co-products, side streams and residual streams**<br>Sustainable management and utilisation of biomass feedstock from different side-, residual and co-product streams. Development of sustainability criteria and circularity metrics for different biomass feedstocks and related biobased products. Ensure safety in material circulation, including cyber safety and health issues. | Objective 1 |
| 2 | **Resource efficient biomass pre-treatments and conversion into competitive products and applications**<br>Develop and demonstrate advanced, energy and carbon efficient, biomass pre-treatment and conversion technologies, such as chemical, thermochemical and biochemical technologies, to produce fuels, energy and especially biobased products to variety of applications (e.g. films, fibres, packaging, structural composites) according to circular principles including cascading processes, capturing and utilising $CO_2$ in processes, and material and product design for reuse or recycling. | Objective 2 and 3 |
| 3 | **Biorefinery process optimisation and integration towards circularity**<br>Develop simulation and modelling tools, process technologies and logistic solutions for biorefinery process optimisation and integration towards cascading and circular approaches. Ensure safety in material circulation. | Objective 2 |

### 4.2.2 Chemicals

Chemicals are at the basis of society in the everyday products we use. Nonetheless some chemicals pose a risk to human health or the environment. The REACH regulation either limits or forbids the use of some chemicals while others are controlled on the initiative of companies and producers, but many hazardous and potentially hazardous chemicals remain in production processes and in products. This constitutes a problem in the recovery and recycling of the products because it perpetuates the presence of substances of concern on the market and therefore its exposure to humans and the environment.

The Chemicals theme contributes to sustainable and healthy industrial production, conscious consumptions and a correct waste management in the EU, to close resource cycles and minimize pollution.

***OBJECTIVES***

The objectives of the Chemicals theme are:

| | |
|---|---|
| **Objective 1.** | To create a demand for healthy materials |
| **Objective 2.** | To innovate materials, formulations and processes, also substituting or limiting the quantity of hazardous materials in products and in markets |
| **Objective 3.** | To increase the traceability of chemicals in products and information to consumers |

***INNOVATION FIELDS***

| | Innovation Field | Corresponding objective(s) |
|---|---|---|
| 1 | **Introduce traceability for chemicals of concern in products**<br>Introducing traceability systems for chemicals of concern (e.g. a scorecard rating for products) and promoting eco-labelling for chemicals of concern in products | Objective 1 and 3 |
| 2 | **Prioritise chemical footprinting in product innovations**<br>Integrate chemical footprint considerations at the front end of innovation in businesses and business decisions, rather than have it be an add-on or afterthought when a business already has significant sunk costs in a new product and is irrevocably down the line on product development decisions. | Objective 2 |
| 3 | **Hazardous chemicals substitution especially in the fields of waterproof and oil-proof materials, preservatives and antimicrobials, plasticisers, protective surface treatments**<br>To develop new processes and encourage product eco-design for substituting hazardous substances, while retaining key properties. Hazardous chemical substitution should especially be focused on the fields of waterproof and oil proof materials, preservatives and antimicrobials, plasticisers and protective surface treatments. The aim of hazardous material substitution is to achieve sustainable production processes, limit the circulation of substances of concern for human health and the environment, and to facilitate safe product recycling without perpetuating the presence of such substances on the market | Objective 1, 2 and 3 |

| | | |
|---|---|---|
| 4 | **Extended producer responsibility**<br><br>Foster extended producer responsibility to improve the effectiveness of developing new business models and build greater public awareness about the need to correctly dispose of old/damaged products from a chemical perspective. | Objective 2 and 3 |
| 5 | **Promoting innovative biochemical production processes**<br><br>Research to produce novel biochemical production processes to sustainably derive fine chemicals with added value as building blocks, advanced intermediates or active ingredients starting materials for specialty chemicals, particularly pharmaceuticals, biopharmaceuticals and agrochemicals. | Objective 2 |

### 4.2.3 Construction and Demolition (including waste)

Construction and demolition waste accounts for approximately 25%-30% of all waste generated in the EU. Material flows related to construction and demolition include concrete, bricks, gypsum, wood, glass, metals, plastic, solvents, asbestos and excavated soil. Given this diversity of materials, the potential for their recovery and recycling from construction and demolition waste streams will also differ greatly from one material to another. A more careful and well-researched use of building materials and technologies is expected to allow for an improved use of construction and demolition waste, both in quality and quantity.

This theme focuses on planning and designing buildings and infrastructure that use building materials that are produced in a resource efficient way, and that allow for a reduced waste generation from future demolition, while maximising the recovery of useful materials from the waste that cannot be avoided.

***OBJECTIVES***

The objectives of the Construction and Demolition Materials (including waste) theme are:

| | |
|---|---|
| **Objective 1.** | To increase recycling and preparation for reuse of waste from construction and demolition activities as to obtain marketable and competitive secondary materials and reusable products. |
| **Objective 2.** | To reduce waste generation from construction and demolition activities. |
| **Objective 3.** | To prevent health risks by avoiding the use of hazardous substances in construction materials and buildings, and by appropriately treating hazardous waste resulting from construction and demolition activities. |
| **Objective 4.** | To remove regulatory barriers for innovation and establish EU-harmonised regulations, criteria and standards on construction materials, selective demolition and C&D waste recycling. |
| **Objective 5.** | To promote the exchange and adoption of best circular and sustainable practices in construction. |
| **Objective 6.** | To reduce resource consumption, waste and emissions related to the production of building materials and to the construction, (re-)use and demolition of buildings. |

***INNOVATION FIELDS***

| | Innovation Field | Corresponding objective(s) |
|---|---|---|
| 1 | **Planning and design for re-use and recycling**<br>Integrating the following aspects in the planning and design phases of buildings to minimise waste generation: reversibility, ease of transformation, deconstruction & disassembly, future reuse and recycling of building components. | Objective 2 |
| 2 | **Effective material recovery and decontamination techniques**<br>Use of effective and flexible techniques for the sorting and recycling of construction and demolition waste (CDW) and for safely managing hazardous CDW, always assuring traceability | Objective 1 and 3 |
| 3 | **Methodologies for assessment of (environmental) life cycle costs**<br>Development of a common framework that enables the assessment of the technical, economic and environmental performance of a building or a construction material over its entire life cycle | Objective 6 |
| 4 | **Technical solutions, regulations, tools for policy makers**<br>The creation of incentives, technical solutions, tools and guidelines for policy makers, that are flexible and adaptable to local features and conditions | Objective 4 and 5 |
| 5 | **Analysis of key properties of construction materials**<br>Research on composition and physico-chemical properties of construction materials improving concrete recycling | Objectives 1 to 6 |

### 4.2.4 Food

Food is a renewable but extremely precious resource. Its management must not be subject to waste either for moral or economic reasons. At any level it is necessary to promote practices that valorise food waste, even in sectors other than food. In a hierarchy that favours human and therefore animal nutrition, the residues must be collected and addressed to other productions or, lastly, to energy recovery.

The Food theme contributes to sustainable, healthy and efficient food production and consumption in the EU, to close resource cycles and minimise waste and pollution.

***OBJECTIVES***

The objectives of the Food theme are:

| | |
|---|---|
| **Objective 1.** | To guarantee food security, food safety and healthy diets as part of circular economy in the food sector |
| **Objective 2.** | To understand future food production and supply chains in Europe including urban-rural interactions |
| **Objective 3.** | To close material and energy cycles and prevent food and packaging waste while minimising emissions by 2050 |

| Objective 4. | To educate eaters on circular food production and consumption systems |
|---|---|

***INNOVATION FIELDS***

| | Innovation Field | Corresponding objective(s) |
|---|---|---|
| 1 | **Smart, sustainable and productive farming systems**<br>Smart and sustainable farming systems (including urban agriculture) that maintain natural resources, increase production efficiency and promote high food quality, sustainability and awareness, characterised by logistical innovations that promote healthy, local and seasonal foods. | Objective 1 and 3 |
| 2 | **Lifecycle mapping and scenario modelling of EU food systems**<br>Mapping and scenario modelling of food systems with the aim to understand food production, supply chain, consumption and transport systems considering urban-rural interactions. Consider issues on food quality and safety, energy balance, economic sustainability, stakeholder attitudes and resource efficiency. | Objective 2 and 3 |
| 3 | **Re-commercialisation of commercial and agricultural food waste**<br>Technological innovations and regulatory changes to recommercialise expired retail and commercial food including related aspects such as transport logistics. For food and organic waste from the agricultural sector, promote and upscale the use of by-products (e.g. crop waste in animal feed, manure in fertiliser and other nutrient recovery from organic wastes). Traceability should be integrated to safeguard human, animal and environmental health, and ensure social acceptance | Objective 3 |
| 4 | **General upscaling of market-friendly circular economy innovations in the food sector**<br>Adopt a systems approach to scale up market-friendly innovations and solutions (e.g. zero-packaging supermarkets) to the mass market for wide commercial adoption | Objective 2, 3 and 4 |

### 4.2.5 Plastic

Plastic is the material of excellence of the last century. The durability, chemical resistance and low cost of plastics has enabled the development and mass-production of many innovative products and technologies. At the same time, these positive qualities are also the main drawback. The short sighted and careless use of plastics has posed critical environmental problems that are undermining the future balance of the planet. Marine litter is already threatening life in the seas. Therefore, the plastics economy must change from a system that produces waste by design to one that preserves the value and benefits of plastics while eliminating or minimising the drawbacks.

The Plastics theme contributes to the sustainable use of plastics, by increasing circular flows and seeking alternatives to plastics where viable.

***OBJECTIVES***

The objectives of the Plastic theme are:

| | |
|---|---|
| **Objective 1.** | To develop fossil-free plastics |
| **Objective 2.** | To transition to smarter plastic use if it is more resource efficient than alternative materials |
| **Objective 3.** | To increase the circularity of plastic flows |

***INNOVATION FIELDS***

| | Innovation Field | Corresponding objective(s) |
|---|---|---|
| 1 | **Design for sustainable plastic consumption and smarter use**<br>Sustainable plastic design includes both material design and design for reuse/ recycling. It also includes contribution to policy development to enhance the importance of design; social aspects and behaviour, etc. Considerations on comparing plastic vs other materials and reducing consumption and dependence on plastics (e.g. alternative materials). | Objective 2 and 3 |
| 2 | **Traceability and information in the plastic value chain**<br>Increasing the traceability and transparency in plastic value chains in terms of resource intensity, chemical composition/process chemical use and lifecycle impacts. | Objective 2 and 3 |
| 3 | **Improve recycling technologies including chemical recycling**<br>Development of recycling technologies to handle more parts of the plastic flows. Including chemical recycling | Objective 2 and 3 |
| 4 | **Biobased plastics in a circular system**<br>Development of biobased plastics, in relation to the existing system, making them circular also in terms of recycling and in some cases degradability. | Objective 1 and 3 |

### 4.2.6 Raw Materials

In the simplest terms, the linear economy model converts raw materials into waste. Virgin raw materials are a limited resource, and often subject to importation and therefore to supply uncertainty. Their recovery and reintroduction in the production process as secondary raw materials in a circular scheme are not only important for economic reasons, but also for the sake of the environment and society.

This theme contributes to the sustainable and efficient consumption of raw materials throughout the value chain, to reduce material and energy intensity while maximising material value and use.

***OBJECTIVES***

The objectives of the Raw Materials theme are:

| | |
|---|---|
| **Objective 1.** | To secure and to trace a sustainable (environmentally, economically and socially) supply of minerals, ferrous and non-ferrous metals, in particular critical raw materials |
| **Objective 2.** | To design low lifecycle footprint material solutions (from raw materials supply to product-service applications, and including manufacturing processes) |
| **Objective 3.** | To enable maximum value usage of products in the economy |
| **Objective 4.** | To implement a responsible end-of-life of products, from waste collection and sorting to recycling and valorisation |

***INNOVATION FIELDS***

| | Innovation Field | Corresponding objective(s) |
|---|---|---|
| 1 | **Mapping & valorisation of secondary feedstock**<br>▪ Design and production processes supporting an increased supply of materials from the optimal mix of primary and secondary sources, to address existing or new applications<br>▪ Scalable solutions for exploring, inventorying and sharing the information about material streams and potential sources for extracting secondary raw materials over European territories, including urban and landfill mining as well as industrial residues | Objective 1 |
| 2 | **Efficient primary mining & resource assessment**<br>▪ Resource/water/energy efficient mining, mineral processing and metallurgy, including for more complex and lower grades ores and minerals, enabling a safe, low environmental and sanitary impact and economically viable exploitation of primary raw materials in Europe<br>▪ Holistic knowledge of global resources, social and environmental conditions of extraction, toxicity, geostrategic and economic factors regarding each of the critical, toxic and technological materials | Objective 1 |

| | | |
|---|---|---|
| 3 | **Eco-design and eco-processes in product design and material use**<br>▪ Strategies for designing products with a minimum lifecycle footprint, relying on the optimal combination of resource efficiency, use of secondary or substitute materials, design-for-usage, traceability and design-for-recycling, in particular relying on the Eco-Design Directive, the Ecolabel Regulation, Extended Producer Responsibility (EPR)<br>▪ Industrial manufacturing solutions enabling minimum resource consumption in the production process, including additive manufacturing, process intensification and quality standards supportingversatile sourcing | Objective 2 |
| 4 | **Advanced remanufacturing processes for safe and efficient material recovery**<br>Processes and logistics for safe and efficient collection, disassembly, recovery and reuse of valuable materials, especially for complex, composite and hazardous assemblies | Objective 3 |
| 5 | **Optimising value per kg of raw material use**<br>Systemic organisational solutions maximising the material usage value, based on product servicing, sharing and operational lifetime optimisation | Objective 3 |
| 6 | **Efficiently aggregating valuable materials in waste collection**<br>Waste circuits ensuring an efficient aggregation of valuable material flows, especially with regards to energy technologies, transport and WEEE | Objective 4 |
| 7 | **Efficient and effective material detection & separation**<br>Cost-efficient, robust and low-environmental impact detection and extractive processes, delivering secondary feedstocks, including for multi-material recovery | Objective 4 |
| 8 | **Safe and efficient product dismantling and sorting**<br>Safe and efficient processes for depolluting and disassembling complex products, aiming at concentrating material rates and enable highly selective recycling | Objective 4 |

### 4.2.7 Waste

Waste is the central term of a circular economy. According to the EC, the circular economy aims to maintain the value of products, materials and resources for as long as possible by returning them into the product cycle at the end of their use, while minimising the generation of waste.

The overall goal of the circular economy is to close material cycles and avoid waste, as well as reuse and recycle materials to the strongest possible extent. However, only certain materials and shares of natural resources can be fully circulated in loops and resources are also needed for the technical recovery of raw materials from waste. In this respect, waste prevention is a further important aspect of the theme.

The Waste theme shall contribute to a more sustainable, healthy and efficient production and consumption system in the EU that closes material cycles and minimises waste and pollution.

The Waste theme is a cross-cutting theme, first, since there is practically no sector without any waste (not even the service sector) and, second, because it is highly relevant in all contexts addressed here like raw materials, water, plastics, chemicals, and biomass and biotechnologies. It is addressed more specifically in the themes like Food theme and Construction & Demolition.

***OBJECTIVES***

The objectives of the Waste theme are:

| | |
|---|---|
| **Objective 1.** | To extend product life cycles of normal and high-tech products to reduce waste quantities |
| **Objective 2.** | To improve the level of information and awareness for industry, trade, consumers and younger generations to reduce waste volumes |
| **Objective 3.** | To advance (digital) waste management technologies for collection and sorting to reduce landfill and incineration |
| **Objective 4.** | To promote low-waste product design to reduce waste quantities |
| **Objective 5.** | To support consumers to make choices towards low-waste products to reduce waste quantities |
| **Objective 6.** | To further improve recycling rates and recycling quality to ensure a higher quality of materials from sorting processes, including chemical recycling and recycling of organic waste |
| **Objective 7.** | To improve policies for waste management & waste prevention |

***INNOVATION FIELDS***

| | Innovation Field | Corresponding objective(s) |
|---|---|---|
| 1 | **Setting up circular business models to extend product lifespan.**<br>Based on pay per use (or sharing model) rather than paying for the product will enable to reduce waste quantities and extend lifetime. Setting up circular business models for remanufacturing and reuse can strengthen the reuse and remanufacturing of used products. | Objective 1 and 4 |
| 2 | **Improve product robustness and reliability (with limited resource use)**<br>Innovative approaches for modularity, circular design, eco-design (e.g., modular smartphones, eco-design kit). Improve material design to facilitate separation, disassembly, recycling, reuse, refurbishment and repair. | Objective 1 and 4 |
| 3 | **Reducing packaging, strengthening waste prevention and reducing returns**<br>This IF consists of multiple aspects as follows:<br>▪ Reducing packaging (innovation in distribution, unpackaged shops, packaging reduction in supermarkets through expansion of the range of unpackaged food products, introduction of reusable packaging).<br>▪ Strengthening waste prevention initiatives by establishing dialogues and networking between political and social actors<br>▪ Building reflexes for the younger generation using the levers "learning by doing" | Objective 2, 5 and 7 |

| | | |
|---|---|---|
| | ▪ Reducing returns (raising consumer and trade awareness for the negative effects of returns and provide alternatives) – Introduction of reusable trade packaging schemes for special product groups and conversion from cardboard boxes to returnable boxes for transporting fruit and vegetables) | |
| 4 | **Advanced and safe waste treatment, sorting and collection for circularity**<br>This IF consists of multiple aspects as follows:<br>▪ Develop new sorting technologies and new technologies for treatment of multi-material products and composite materials. Quick and affordable methods to detect SVHC in waste stream. Develop laser assisted sorting technologies for sorting of mixed metal alloy. Improve sorting for better recycling (detectors for black plastics, fluorescent markers).<br>▪ Develop treatment technologies for new products arising in the collection streams (e.g. photovoltaic panels, batteries from ELV). Flexible waste treatment technologies and systems that can relatively easily be adapted to changing waste streams. Application of chemical markers as a solution coupling complex product development with better materials sorting, with strong focus on non-metallic fractions. The marking systems should be linked to the sorting methods. High environment and health protection in treatment plants.<br>▪ Exploring smart waste bins and platforms for monitoring, route optimisation. The development of the innovative intelligent bins for different types of wastes which enable efficient collection of waste and facilitate efficient use of the material according to the CE principles.<br>▪ Testing sensor-supported waste collection with weight measurement or electronic sensors in containers to manage remotely collection systems. | Objective 3, 6 and 7 |
| 5 | **Innovations to accelerate recycling and secondary markets**<br>This IF consists of multiple aspects as follows:<br>▪ Innovative systems that improve the traceability of materials and chemicals in the supply chain to stimulate re-use and recycling.<br>▪ Improving secondary resources distribution for industrial symbiosis.<br>▪ Build system, technology and policy design to facilitate and accelerate the development of a competitive market and economy for recycled materials.<br>▪ Stimulating the demand for secondary raw materials through quality requirements and harmonised end-of waste criteria. | Objective 3 and 6 |

### 4.2.8 Water

Water is an extremely limited resource, the use of which must be made more efficient in industrial systems, agriculture and also by consumers in urban areas. It is monitored by legislation, imposing controls either on distributed water and on collected water, to check its quality, prevent contamination and encourage its use in closed circuits.

This theme focuses on to the sustainable and efficient use of water in both industrial, commercial and household consumption.

***OBJECTIVES***

The objectives of the Water theme are:

| | |
|---|---|
| **Objective 1.** | To achieve a water-wise and bio-based economy that closes the water cycle gap, enables efficient water treatment technologies and smart water systems, improves urban water system safety and quality (especially risks associated with emerging pollutants and water infrastructural accidents), and ensures adequate water access without single-use plastic bottles. |
| **Objective 2.** | To enhance regulatory frameworks for efficient water use and management. |

***INNOVATION FIELDS***

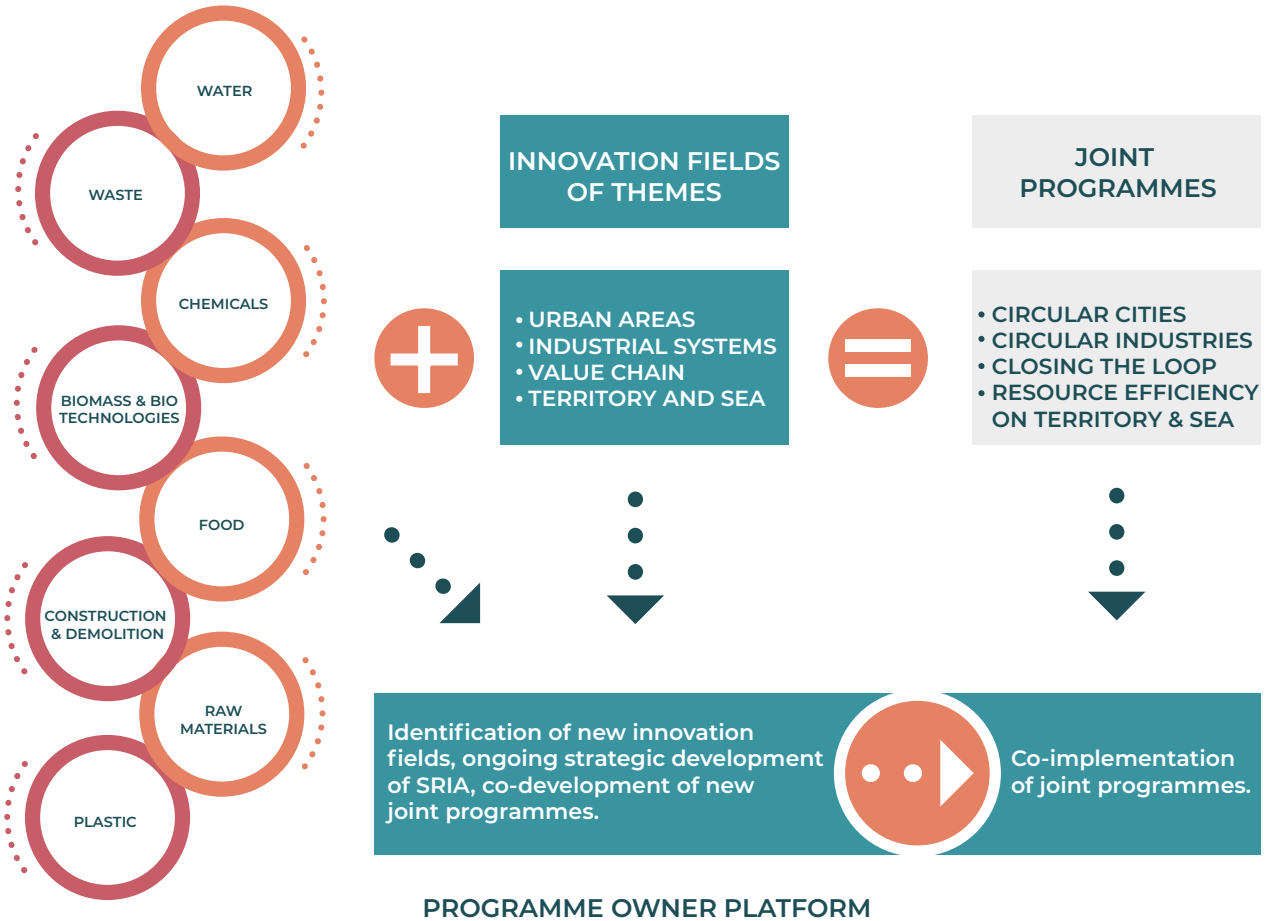
| | Innovation Field | Corresponding objective(s) |
|---|---|---|
| 1 | **Advanced wastewater treatment for material recovery and safety**<br>Advanced, cost-effective industrial and urban wastewater treatment technologies characterised by the recovery of valuable products and pollutants (e.g. metals, minerals, nutrients and chemicals), microplastic filtration/treatment and water capture and reuse from agricultural liquid and solid wastes. This may also involve increasing operational efficiency of wastewater treatment facilities. | Objective 1 |
| 2 | **Integrated water network systems for resilience and securing supply**<br>Integrated water network systems with improved resilience and capacity, that boost the performance of rainwater drainage networks (preferably using nature-based solutions) and increase supply for potable water and irrigation. | Objective 1 |
| 3 | **Holistic water management integrating technology, socioeconomics and policy**<br>Integration between technological innovations, socioeconomic research and policy/ financial incentives to facilitate sustainable water management | Objective 1 and 2 |

# 5 Guidance Programme Owners to Use the SRIA

# 5. Guidance for Programme Owners to Use the SRIA

This guidance applies to programme owners of the SRIA (i.e. those working in government and funding agencies coordinating research and innovation programmes) as members of the programme owners' platform.

As described in the previous sections, the SRIA consists of four joint programmes, which are the basis for programme owners to co-create, co-fund and work together towards systemic circular economy. The joint programmes were developed by identifying and strategically linking areas of research and innovation (innovation fields) across eight themes within four high-level challenges. The existing eight themes are Biomass and Biotechnologies, Chemicals, Construction and Demolition, Food, Plastic, Raw Materials, Waste and Water. The existing four challenges are urban areas, industrial systems, value chain and territory and sea. This is illustrated in the diagram below.



**The CE SRIA was developed by identifying innovation fields across eight themes and four societal challenge areas, out of which four joint programs were formed. Members of the programme owner platform are expected to use both the joint programmes and innovation fields to collaborate on circular economy programming. These aspects of the SRIA can also be tailored to their needs.**

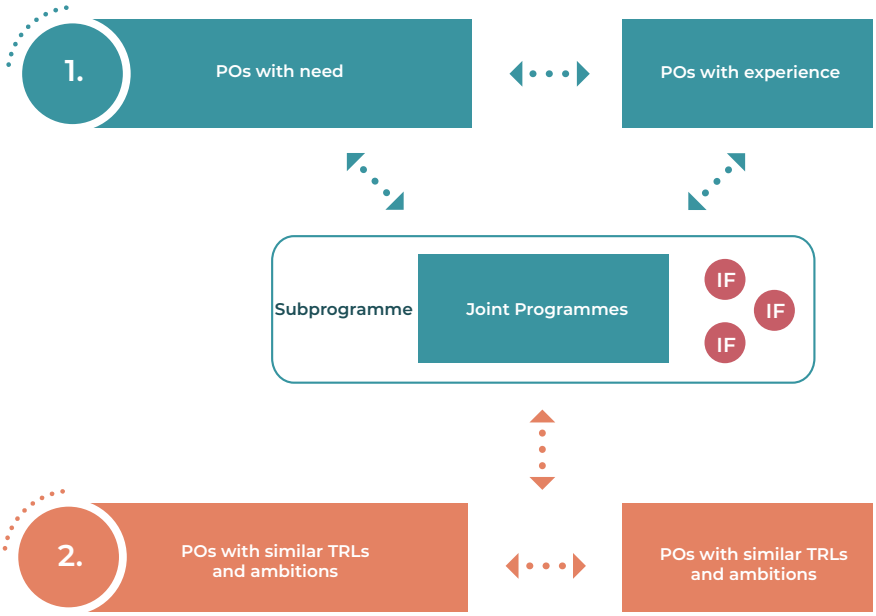
There are two main ways for programme owners to use this SRIA;

1. The first is the co-implementation of joint programmes and
2. The second is to use the SRIA as a framework to identify new areas of research and innovation (i.e. innovation fields) and develop new joint programmes for further collaboration. These two ways of using the SRIA is further described below.

## 5.1 Co-implementation of Joint Programmes (i.e. Joint Programming)

The SRIA serves as a framework for cooperation through joint programming, when programmes and subprogrammes could be used for identification of the needs for joint programming and evaluation of experience levels. This allows matching POs for two types of cooperation:

1. **POs with needs and POs with experience.** The POs with needs on certain R&I priorities could be matched with the POs with experiences in these fields. The POs with experiences should share their best practices and challenges, monitoring practices etc., that allows POs with needs to implement joint programming in the most efficient way to save time and resources.
2. **POs with similar needs and advancements.** The POs with similar needs, advancements and ambitions in innovations could be matched together to jointly tackle the circular economy transition needed to achieve their respective sustainability targets (including shared targets such as those set in the Paris Agreement, EU Green Deal and EU Circular Economy Action Plan).




**Two ways of matching POs within the SRIA**

Joint programmes are structured and strategic R&I programmes that define, in further detail, the specific activities, necessary disciplines and actors that could be involved in R&I actions. The examples serving as guidance for drafting the joint calls can be found in the SRIA's example joint calls the sections below:

- 3.1.1 Pilot Joint Call – Circular Cities
- 3.2.1, Pilot Joint Call – Circular Industries
- 3.3.1 Pilot Joint Call - Closing the Loop
- 3.4.1 Pilot Joint Call - Resource Efficiency on Territory and Sea.

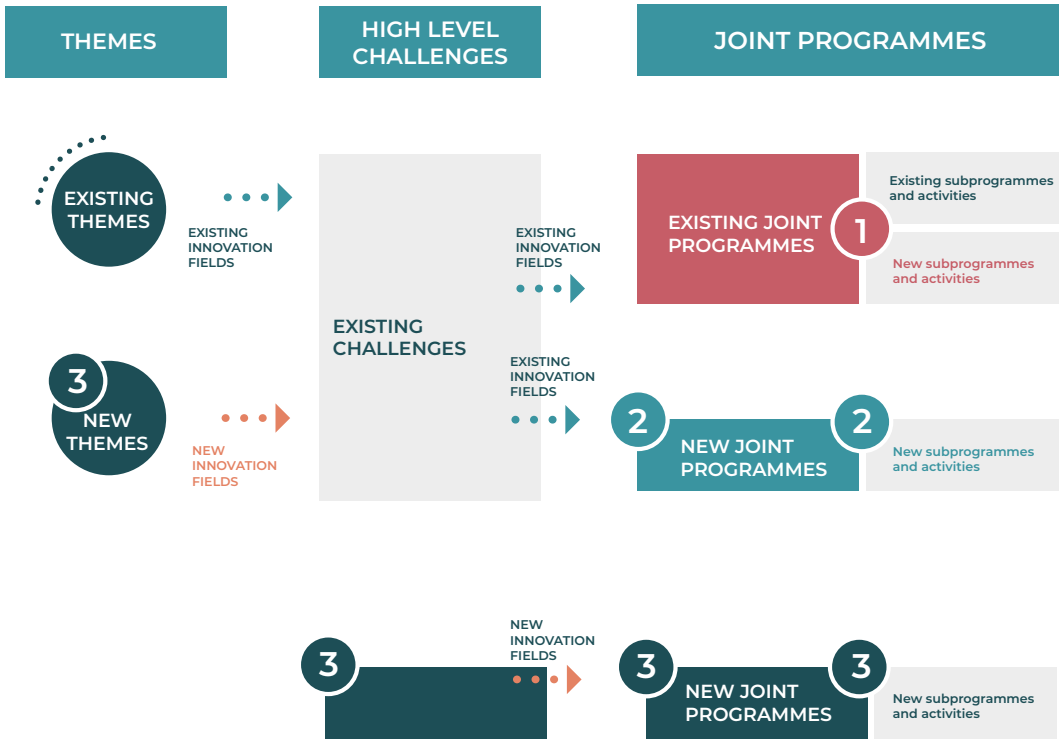
## 5.2 Using the SRIA framework for future joint programming work

The joint programmes of the SRIA focus on cross-cutting and transdisciplinary aspects to bring about systemic changes and represent examples and templates of how systemic programmes can be built. However, key priorities, issues, targets and strategies are changing on an ongoing basis, thus over time it will be necessary to update/ develop new SRIA elements in order to ensure its continual relevance and value for programme owners.

There are three main ways that programme owners can use the SRIA as a framework for future joint programming work:

1. Developing new subprogrammes and activities within the four existing joint programmes in the SRIA;
2. Developing new joint programmes using the pre-identified areas of priority research and innovation fields in Section 4. Research and Innovation Priority Areas (Innovation Fields);
3. Identifying new themes, challenges and the respective priority research and innovation areas (i.e. innovation fields) and adding or revising them to the framework of the SRIA. These can then form new joint programmes as well.

This is also illustrated in the figure below.




**Three main ways for programme owners to update and keep use of the SRIA in the future: 1) developing new subprogrammes and activities in existing joint programmes, 2) developing new joint programmes from existing innovation fields, and 3) adding new themes, challenges and innovation fields to form new joint programmes.**

The joint programming platform will support POs to use and update the SRIA as one of its core services, including the identification of those responsible on coordinating the revisions of the SRIA and how often such revisions should be made. The methodology used for developing this SRIA (see ANNEX I: SRIA Methodology) can be used as a reference for developing the process to update the SRIA in the future.

# 6 Alignment of SRIA to Major EU Initiatives

# 6. Alignment of SRIA to Major EU Initiatives

## 6.1 The European Green Deal

The European Green Deal was formed to face the climate and environmental challenges threatening the EU and its citizens. The Green Deal is a growth strategy that aims for economic growth to be decoupled from resource use and with no net emissions of greenhouse gases in 2050. The Green Deal includes several actions in a roadmap and was launched in 2019.

In general, the European Green Deal covers a broader scope and includes actions on a higher level compared to the SRIA, which is more detailed and more operational with the joint programmes, innovation fields and the objectives. Nonetheless, the SRIA aligns well in contributing to the goals set out in the Green Deal, especially when it comes to the industrial strategy and the Circular Economy Action Plan that is part of the Green Deal. For example, the Circular Cities joint programme and its activities related to construction and demolition aligns well with the Renovation Wave in the building sector described in the Green Deal. Activities related to food and territory and sea also aligns with the Green Deal's "Farm to Fork Strategy". The SRIA even goes further by considering the citizen perspective in achieving the high-level objectives set out in the Green Deal.

## 6.2 The Circular Economy Action Plan

In December 2015 the European Commission introduced the EU Circular Economy Action Plan, a package of different initiatives to encourage the transformation into a circular economy. As of March 2019, the 54 actions of the Plan have been implemented.

The SRIA aligns well and builds on the Action Plan, especially on the areas of Chemicals, Biomass and Biotechnologies, Plastics, Raw Materials and Waste. In some cases, the SRIA even goes beyond the Action Plan in, for example, activities on water to consider the household perspective, as well as within the Circular Industries joint programme where industrial symbiosis and industrial ecology are highlighted.

A new Circular Economy Action Plan was published in 2020, in which electronics and electrical products, some plastic products and textiles are especially challenging from a circular economy standpoint. Electronics and textiles were not prioritised themes in the CICERONE project, but linkages have been made between these sectors and the joint programme activities of the SRIA.

The SRIA align well with the ambitions of the new Action Plan to boost the transformation towards a circular economy. It is necessary to promote sustainable products in the market and encourage consumers to be active in the circular economy. The SRIA and the new Action Plan are aligned on this as well as prioritising the reduction of waste generation and developing a robust market for secondary raw materials.

The alignment between the SRIA's subprogrammes and the priority areas of the new CEAP is summarised in the table below.

| SRIA Subprogrammes | Relevant EU CEAP Priority Areas | | | | | | |
|---|---|---|---|---|---|---|---|
| | Plastics | Food, water and nutrients | Batteries and vehicles | Construction and buildings | Packaging | Textiles | Electronics and ICT |
| **CIRCULAR CITIES** | | | | | | | |
| 1.1: Infrastructure to enable circular material and product flows | X | X | X | X | X | X | X |
| 1.2: Citizen participation in circular materials and products flows | X | X | X | X | X | X | X |
| 1.3: Slowing down materials and product flows (various sectors) | X | | | | | X | X |
| 1.4: Decreasing the size of material flows in the food retail sector while increasing material efficiency | X | X | | | | | |
| 2.1: Circular economy considerations of water and soil in food systems | | X | | | | | |
| 2.2: Circular economy considerations for land and soils in construction and urban planning | | X | | X | | | X |
| 2.3: Circular economy considerations in water supply and treatment systems | | X | | | | | |
| 2.4: Shifting towards circular water systems in buildings | | | | X | | | |
| **CIRCULAR INDUSTRIES** | | | | | | | |
| 1.1: To develop new technologies for new materials production | X | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.2: To develop quality standards and analytic methods for materials production and characterisation | X | X | | | | X | X |
| 1.3: To develop new technologies for resource and waste characterisation | X | X | | | | X | X |
| 2.1: Smart Factories - Building SME partnerships, “alliances of interests” and industrial symbiosis networks | | X | | | | | X |
| 3.1: Promote eco-design and eco-processes | X | | | | | X | X |
| 3.2: Promote re-use, repair and remanufacturing | X | X | X | X | X | X | X |
| 4.1: GHG accounting and management system (individual company*) | X | X | X | X | X | | |
| 4.2: Promoting secondary raw materials market and industry | X | X | X | X | X | X | X |
| 4.3: Reduce the carbon/ GHG emissions in industrial systems | X | X | X | X | X | X | X |
| **CLOSING THE LOOP** | | | | | | | |
| 1.1: Circular complex product design | X | X | | X | | X | |
| 1.2: Circular business model strategies for complex products | X | X | | | | X | X |
| 2.1: Circular design and technical development for human and environmental health | X | | | | | X | X |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.2: Circular business model for human and environmental health | X | X | X | X | X | X | X |
| 3.1: Traceability and management of raw materials | X | | X | X | | X | X |
| 3.2: Promoting market viable solutions for circular economy Rationale for the programme | X | X | | | | X | X |
| **RESOURCE EFFICIENCY ON TERRITORY AND SEA** | | | | | | | |
| 1.1: Transition to a circular and sustainable shipping industry | X | | | | | | X |
| 2.1: Transition to integrated resource management approaches working at the territorial level with a holistic and circular perspective | X | X | | | | | |
| 2.2: Transition to a sustainable fishing and circular aquaculture sector | | X | | | | | |

## 6.3 Horizon Europe

The new €100 billion research and innovation programme is called Horizon Europe. This programme will succeed Horizon 2020 during 2021-2027 and is divided into five mission areas;

1 Adaptation to climate change including societal transformation

2 Cancer

3 Climate-neutral and smart cities

4 Healthy oceans, seas, coastal and inland waters

5 Soil health and food

Most of the SRIA's joint programmes are aligned with the missions. For example, the Circular Cities joint programme of the SRIA aligns with the mission on Climate-neutral and smart cities, and the Resource Efficiency at Territory and Sea joint programme aligns with the Healthy oceans, seas, coastal and inland waters mission. The only mission that is not so relevant for the SRIA is the Cancer mission.

The programme is also divided into three different pillars where number two, Global Challenges and European Industrial Competitiveness have six different clusters. The SRIA's activities on food and biomass and biotechnologies align well with one cluster called Food, Bioeconomy, Natural Resources, Agriculture and Environment.

The SRIA helps to identify the research direction for Horizon programme development particularly as the programme develops in the future. The Closing the Loop joint programme, for example, has an objective that directly feeds into the Horizon Europe Programme.

# 7 Conclusion

# 7. Conclusion

Public funding is an important source of financing for Circular Economy (CE) oriented research and innovation (R&I) programmes at both national, regional and European levels. In many cases, CE is often not well defined nor directly addressed in all funding programmes. Sometimes the focus lies on specific sectors or CE is not always considered in a systemic way leaving behind some aspects of the value chain.

This SRIA is developed within the CICERONE project, as a strategic guidance document that specifically focuses on the topic of CE in the European Union. The SRIA targets national, regional and local funding agencies (programme owners) coordinating research and innovation programmes in order to identify joint priorities in research and innovation, co-implement joint programmes and serve as a framework for further cooperation. Collaboration will be based on the SRIA's joint programmes, which provide a framework for a more systemic innovation aiming to create holistic, cross-cutting and systemic programmes with greater impacts.

The SRIA is developed on eight priority themes (Biomass and Biotechnologies, Chemicals, Construction and Demolition, Food, Plastic, Raw Materials, Waste and Water). The themes build on four societal areas that face sustainability challenges (urban areas, industrial systems, value chains and territory and sea) to identify priority areas (Innovation fields) for CE research and innovation that tackle EU region-wide issues and facilitate the CE transition. Based on the Innovation fields, four joint programmes were developed in this SRIA: Circular Cities, Circular Industries, Closing the Loop and Resource Efficiency on Territory & Sea.

The SRIA provides an overview of four joint programmes, which could be implemented throughout several corresponding subprogrammes. Within each of the subprogrammes, the predicted activities and relevant actors are listed, that could serve as an inspiration/examples for joint programming and/or joint funding by project owners.

The SRIA aligns with the main EUs strategic documents, such as the European Green Deal and the Circular Economy Action Plan. The four SRIA joint programmes tend to contribute, rather than duplicate, the ambitions and the efforts of the European strategies and initiatives. In this way, the SRIA provides a deeper added value not only by providing a basis for programme owners to join forces working on CE research and innovation, but also in contributing to sustainable socio-economic development in the EU.

As key priorities, issues, targets and strategies are changing on an ongoing basis, the SRIA's elements are intended to be updated or the new ones to be developed when the SRIA is used for future cooperation. A detailed methodology on how the joint programmes were developed is presented in the SRIA and might serve as a basis for the future updating and development of the SRIA.

The SRIA will be used by programmes owners on the PO platform to collaborate and implement research and innovation actions. Such collaboration can contribute significantly to the acceleration of the EU's systemic transition to the circular economy.

# LIST OF ANNEXES

# ANNEX I: SRIA Methodology

Meeting societal, environmental and economic needs and creating system change are the foundation of developing the SRIA. This was achieved in a three-stage approach:

1. Mapping circular economy objectives and deriving fields where innovation is to be supported, i.e. innovation fields
2. Prioritising the innovation fields based on feasibility and potential impact
3. Developing the joint programmes

Stakeholder engagement was a critical component throughout the SRIA development process. Stakeholder engagement and consultation activities targeted programme owners at the national, subnational (regional) and local levels. They also included experts, academia, government/policymakers, SMEs and businesses, industry, NGOs and civil society groups. The SRIA was developed by a task group in the CICERONE project consisting of over ten expert organisations from November 2019 to June 2020.

This annex provides a summary of the methodology used to develop the SRIA. The full methodology can be found in the CICERONE deliverable D1.4: Framework for a Circular Economy Strategic Planning (Witomski, 2020)[25].

## Stage 1. Mapping circular economy objectives and deriving fields where innovation is to be supported, i.e. innovation fields

Before the SRIA, European strategies and initiatives on circular economy research and innovation (e.g. eco-design, repair, industrial symbiosis) were, in general, fragmented. The first step of this task was to comprehensively map out objectives related to aspects of the circular economy. This was mainly based on the key findings of earlier tasks in the CICERONE project. This includes *T1.1 Benchmarking of CE programs in the EU,* and *T1.2 benchmarking of international CE programs* which mapped out the major circular economy research and innovation programmes in the EU and internationally, identified key trends in the scope and advancement of CE-related activities. A case study was conducted of existing joint research and innovation programmes in the EU to identify gaps and lessons learned that can be useful for the SRIA. Further, a set of relevant strategic research and innovation agendas (SRIAs) were compiled and analysed as background input to this task. Finally, stakeholder inputs were collected during the first CICERONE stakeholder consultation workshop in Feb 2019 in Antwerp. The findings of these activities served as inputs to the first building blocks of the SRIA.

The objectives were identified and synthesised under each of the four societal challenge areas and eight themes. For each objective, the innovation fields were defined. They formed areas of research and innovation that are oriented towards functionality and usage value and were formulated as to address clear requirements and encompass technical and scientific solutions. The outcome were raw lists of circular economy objectives and innovation fields for each theme and challenge.

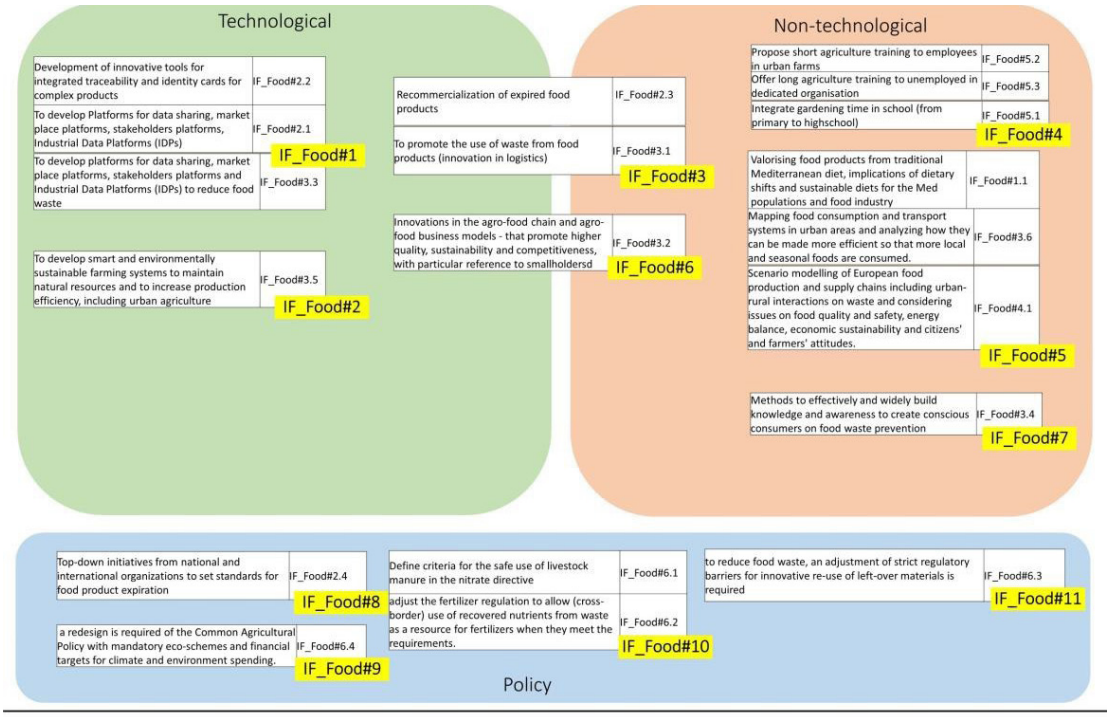
The raw list of circular economy objectives and innovation fields were used as the basis of online consultation (May to Aug 2019) on the Assembl platform for programme owners and key stakeholders to critique, discuss and return feedback.

## Stage 2. Prioritising the innovation fields based on feasibility and potential impact

This stage of the task consisted of several steps: 1) synthesis of the objectives and IFs compiled as a result of the online consultation, 2) engaging all CICERONE partners to evaluate and prioritise the synthesised IFs, and 3) final compilation of the objectives and IFs.

In the first step, a method was developed for all theme and challenge leaders to review the objectives and IFs separately and integrate relevant comments as appropriate. Then, overlapping objectives were collated, grouped, and reformulated (if necessary) to produce a synthesised list of objectives. The same was done for the IFs. The result was a refined, synthesised list of objectives and IFs for each theme and challenge.

[25] This is a deliverable under the CICERONE project, to be published by the European Commission.




Food – IF grouping canvas

**Example of the IF synthesis process for the FOOD theme. This consisted of collating and grouping overlapping IFs and reformulating them where necessary.**

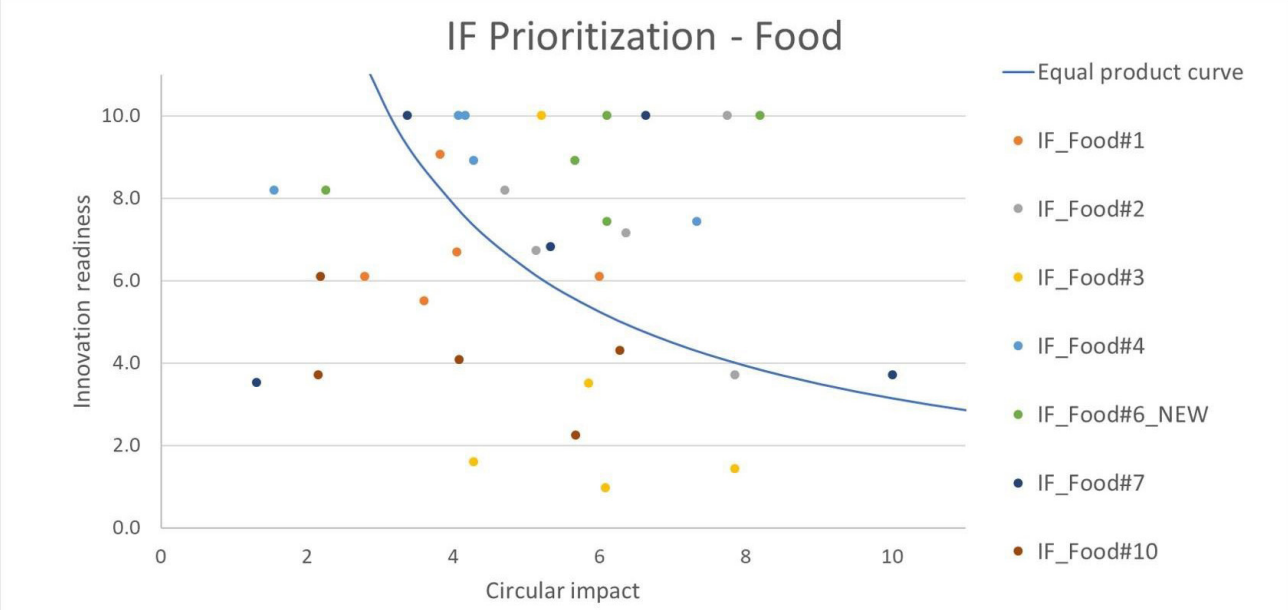
Next, the synthesised lists of objectives and IFs were shared with the rest of the CICERONE partners in an internal evaluation. The aim was to determine the circular impact and innovation readiness of each IF, identify the relevance between the theme-based IFs with the challenges, and to collect input on joint programming-related aspects of the IFs. A numerical score was calculated for each impact and feasibility category. The evaluation was conducted in Sep 2019.

| Circular impacts | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Environmental impacts | | | Social impacts | | | Economic impacts | | | Indirect impacts | | |
| **Reduces GES footprint** (incl. energy use) | **Reduces material footprint** (especially Rare/critical/ hazardous matters) | **Reduces footprint on biodiversity / local environment** (incl. water/soils pollution, nuisance for fauna, etc.) | **Creates/ maintains local jobs** | **Supports a better social inclusion** (gender equality, inclusion of low qualified/ disabled/migrant workers, etc.) | **Favors a balanced territorial development** (support short circuits, activities for rural/isolated areas..) | **Creates wealth** | **Strengthen ecosystems** (increases coherence, completion, resilience) | **Reduces EU dependencies** (especially to critical materials) | **The IF is a CE enabler for...** (qualify the IF contribution to leveraging CE potential ; only if direct impacts are not assessed) | **Criticality from CE enabling IFs** (to be filled in only if direct impacts not assessed) | **Circular impact synthetic mark** |
| | | | | | | | | | | | |

**Criteria used for evaluating potential impacts.**

The SRIA team further reviewed the results and critically examined the IFs against the innovation focus of the future SRIA. It was decided that the SRIA should focus on technological and socioeconomic disciplines to promote circular economy innovation, and that IFs generally pointing towards policy development, capacity building and education would be more suitable as services on the programme owner platform. They were thus transferred to the team responsible for the platform in the CICERONE project.

The identification of priority IFs was based on a calculation of the median of the impact and feasibility scores from all respondents to produce an equal product curve, which formed a threshold to determine which IFs would be prioritised for inclusion in the SRIA and which would be excluded.




**Example of a prioritisation graph for IFs in the FOOD theme. Each coordinate represents input from one partner who participated in the evaluation of the theme. In general, IFs that had the majority of coordinates on the right side of the equal product curve (i.e. the threshold for determining prioritisation) was prioritised for inclusion in the SRIA.**

Finally, the SRIA team reviewed the list of prioritised innovation fields for each theme and categorised and allocated them to the four societal challenge areas based on relevance. For example, certain IFs from the food and waste themes were categorised into the challenge area Urban Areas, while others were categorised into Industrial Areas. At times the theme-based IFs would be allocated in multiple challenge areas if they were deemed relevant.

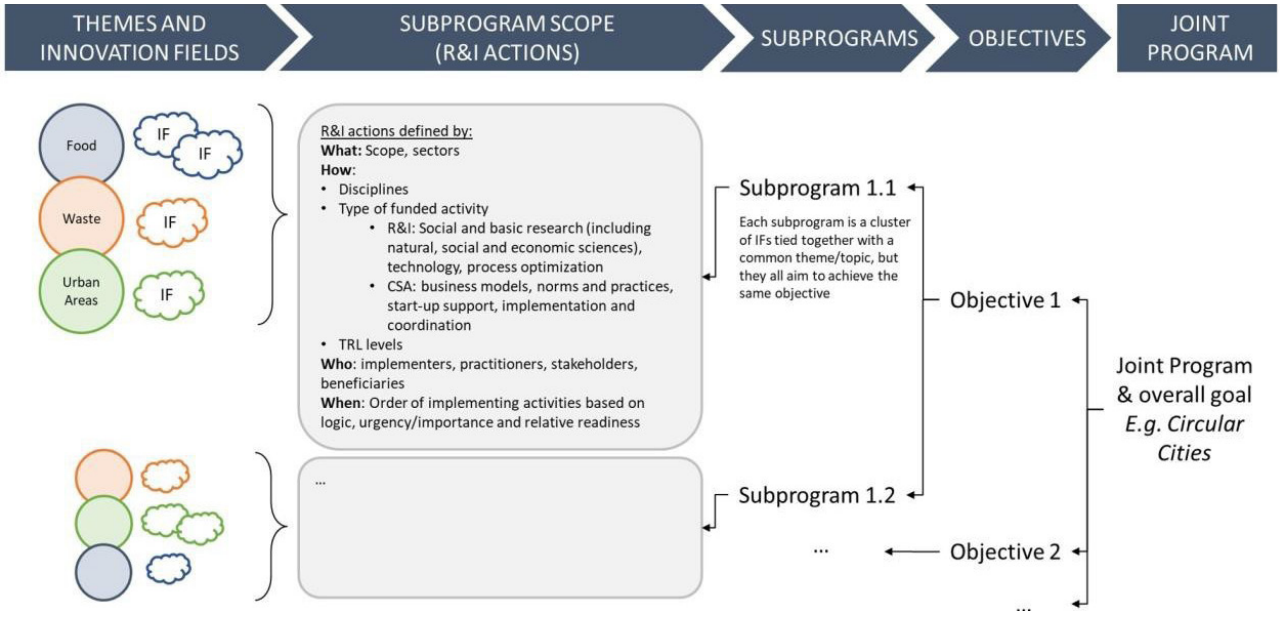
The outcome of this stage is a list of prioritised innovation fields for each societal challenge area: Urban Areas, Industrial Systems, Value Chains and Territory and Sea. Each challenge area consists of prioritised IFs for relevant themes and the challenge area itself.

### Stage 3. Developing the joint programmes

Each joint programme was developed based on the prioritised IFs of each challenge area (consisting of IFs from both the themes and the challenge area itself). This is illustrated in the table below.

| IFs from Themes | | IFs from the Challenge Areas | | Joint Programmes |
|---|---|---|---|---|
| 1. Biomass and biotechnologies<br>2. Chemicals<br>3. Construction and demolition<br>4. Food<br>5. Plastic<br>6. Raw materials<br>7. Waste<br>8. Water | + | Urban Areas<br>Industrial Systems<br>Value Chains<br>Territory and Sea | = | Circular Cities<br>Circular Industries<br>Closing the Loop<br>Resource Efficiency on Territory and Sea |

The objectives for each joint programme are taken from the objectives of the respective societal challenge area. For each objective, the innovation fields were strategically combined to develop subprogrammes and activities. This allowed for the joint programmes to be transdisciplinary and trans-sectoral, by linking together synergetic innovation fields between the themes. This is illustrated in the diagram below.




**Overview of the joint programme development method. Each joint programme is split further into subprogrammes, which is formed by a cluster of innovation fields that are tied together with a common theme/topic, addressing innovations across multiple sectors to achieve the same objective.**

The joint programmes were developed based on a joint programme prototyping exercise in collaboration with programme owners and other stakeholders at the second CICERONE workshop in Nov 2019 in Berlin, and further elaborated added by the SRIA team.

The joint programmes were then drafted into the overall SRIA report and reviewed again, first by all CICERONE partners and experts followed by a targeted online consultation with programme owners and the CICERONE advisory board. The feedback and inputs were compiled and integrated to produce the final SRIA, first published in June 2020.

# ANNEX II: Innovation fields and relevant EU CEAP priority areas for each subprogramme

The activities developed in the SRIA's subprogrammes are based on pre-identified relevant innovation fields (i.e. broad areas of research and innovation). This annex lists the innovation fields for each subprogramme as well as relevant priority areas of the New EU Circular Economy Action Plan that the subprogramme aligns with.

## 1. Circular Cities

**Objective 1: Enabling urban circularity and increasing citizen engagement in circular solutions**

**Subprogramme 1.1: Infrastructure to enable circular material and product flows**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Urban Areas | 1 | Citizen involvement for circular and sharing economy | Plastics<br>Food, water and nutrients<br>Batteries and vehicles<br>Construction and buildings<br>Packaging<br>Textiles<br>Electronics and ICT |
| | 2 | Circular systems for used products | |
| | 4 | Advanced water treatment systems to promote circularity | |
| | 5 | Advanced waste management systems for circularity | |
| Construction & Demolition | 1 | Planning and design for reuse and recycling | |
| Raw Materials | 6 | Efficiently aggregating valuable materials in waste collection | |
| Waste | 4 | Advanced and safe waste treatment, sorting and collection for circularity | |

**Subprogramme 1.2: Citizen participation in circular materials and products flows**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Urban Areas | 1 | Citizen involvement for circular and sharing economy | Plastics<br>Food, water and nutrients<br>Batteries and vehicles<br>Construction and buildings<br>Packaging<br>Textiles<br>Electronics and ICT |
| | 4 | Advanced water treatment systems to promote circularity | |
| Raw Materials | 6 | Efficiently aggregating valuable materials in waste collection | |

**Subprogramme 1.3: Slowing down materials and product flows (various sectors)**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Urban Areas | 1 | Citizen involvement for circular and sharing economy | Plastics<br>Textiles<br>Electronics and ICT |
| | 2 | Circular systems for used products | |
| Waste | 1 | Setting up circular business models to extend product lifespan. | |
| | 3 | Reducing packaging, strengthening waste prevention and reducing returns | |
| Chemicals | 1 | Introduce traceability for chemicals of concern in products | |
| Raw Materials | 5 | Optimising value per kg of raw material use | |

**Subprogramme 1.4: Decreasing the size of material flows in the food retail sector while increasing material efficiency**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Urban Areas | 1 | Citizen involvement for circular and sharing economy | Plastics<br>Food, water and nutrients |
| Chemicals | 1 | Introduce traceability for chemicals of concern in products | |
| Food | 3 | Re-commercialisation of commercial and agricultural food waste | |
| | 4 | General upscaling of market-friendly circular economy innovations in the food sector | |
| Waste | 3 | Reducing packaging, strengthening waste prevention and reducing returns | |

**Objective 2: To improve resource management (water and soils) in urban and suburban areas, and areas with industrial agriculture**

**Subprogramme 2.1: Circular economy considerations of water and soil in food systems**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Food | 2 | Lifecycle mapping and scenario modelling of EU food systems | Food, water and nutrients |
| | 3 | Re-commercialisation of commercial and agricultural food waste | |
| | 4 | General upscaling of market-friendly circular economy innovations in the food sector | |
| Raw Materials | 5 | Optimising value per kg of raw material use | |
| | 6 | Efficiently aggregating valuable materials in waste collection | |

**Subprogramme 2.2: Circular economy considerations for land and soils in construction and urban planning**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Urban Areas | 4 | Advanced waste management systems for circularity | Food, water and nutrients<br>Construction and buildings<br>Electronics and ICT |
| Construction and Demolition | 1 | Planning and design for re-use and recycling | |
| | 4 | Technical solutions, regulations, tools for policy makers | |
| Raw Materials | 6 | Efficiently aggregating valuable materials in waste collection | |
| Waste | 4 | Advanced and safe waste treatment, sorting and collection for circularity | |

**Subprogramme 2.3: Circular economy considerations in water supply and treatment systems**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Urban Areas | 4 | Advanced water treatment systems to promote circularity | Food, water and nutrients |
| | 5 | Advanced waste management systems for circularity | |
| Raw Materials | 5 | Optimising value per kg of raw material use | |
| | 6 | Efficiently aggregating valuable materials in waste collection | |
| Water | 1 | Advanced wastewater treatment for material recovery and safety | |
| | 2 | Integrated water network systems for resilience and securing supply | |
| | 3 | Holistic water management integrating technology, socioeconomics and policy | |

**Subprogramme 2.4: Shifting towards circular water systems in buildings**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| **Urban Areas** | **1** | Citizen involvement for circular and sharing economy | Construction and buildings |
| **Water** | **2** | Integrated water network systems for resilience and securing supply | |
| | **3** | Holistic water management integrating technology, socioeconomics and policy | |

## 2. Circular Industries

**Objective 1: To develop new technologies, quality standards and analytic methods for new materials production and resource and waste characterisation**

**Subprogramme 1.1: To develop new technologies for new materials production**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| **Industrial Systems** | **3** | Biorefineries support | Plastics |
| **Biomass and Biotechnologies** | **3** | Biorefinery process optimisation and integration towards circularity | |
| **Chemicals** | **2** | Prioritise chemical footprinting in product innovations | |
| | **4** | Extended producer responsibility | |
| | **5** | Promoting innovative biochemical production processes | |
| | **3** | Hazardous chemicals substitution | |
| **Plastics** | **4** | Biobased plastics in a circular system | |

**Subprogramme 1.2: To develop quality standards and analytic methods for materials production and characterisation**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| **Industrial Systems** | **2** | Digitalisation and circular economy research and projects | Plastics<br>Food, water and nutrients<br>Textiles<br>Electronics and ICT |
| **Chemicals** | **2** | Prioritise chemical footprinting in product innovations | |
| | **3** | Hazardous chemicals substitution | |
| | **4** | Extended producer responsibility | |
| **Plastics** | **2** | Traceability and information in the plastic value chain | |
| **Raw Materials** | **2** | Efficient and effective material detection & separation | |
| | **8** | Safe and efficient product dismantling and sorting | |

**Subprogramme 1.3: To develop new technologies for resource and waste characterisation**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| **Industrial Systems** | **2** | Digitalisation and circular economy research and projects | Plastics<br>Food, water and nutrients<br>Textiles<br>Electronics and ICT |
| **Biomass and Biotechnologies** | **1** | Sustainable management of biomass feedstocks from co-products, side streams and residualstreams | |
| **Plastics** | **2** | Traceability and information in the plastic value chain | |
| | **3** | Improve recycling technologies including chemical recycling | |
| **Raw Materials** | **1** | Mapping & valorisation of secondary feedstock | |
| | **2** | Efficient primary mining & resource assessment | |
| | **6** | Efficiently aggregating valuable materials in waste collection | |
| | **7** | Efficient and effective material detection & separation | |
| | **8** | Safe and efficient product dismantling and sorting | |
| **Water** | **1** | Advanced wastewater treatment for material recovery and safety | |

**Objective 2: To enable industrial symbiosis networks and foster digitalisation to master the complexity of products, processes and systems**

**Subprogramme 2.1: Smart Factories - Building SME partnerships, "alliances of interests" and industrial symbiosis networks**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Industrial Systems | 1 | High value manufacturing integrating eco- design | Food, water and nutrients<br>Electronics and ICT |
| | 2 | Digitalisation and circular economy research and projects | |
| Biomass and Biotechnologies | 1 | Sustainable management of biomass feedstocks from co-products, side streams and residual stream | |
| Food | 2 | Lifecycle mapping and scenario modelling of EU food systems | |
| | 3 | Re-commercialisation of commercial and agricultural food waste | |
| Raw Materials | 1 | Mapping & valorisation of secondary feedstock | |
| | 6 | Efficiently aggregating valuable materials in waste collection | |
| | 7 | Efficient and effective material detection & separation | |
| Waste | 5 | Innovations to accelerate recycling and secondary markets | |
| Water | 4 | Advanced wastewater treatment for material recovery and safety | |
| | 3 | Holistic water management integrating technology, socioeconomics and policy | |

**Objective 3: To raise awareness of industrial ecology by promoting new/ better design and use of products and better re-use of materials already in circulation**

**Subprogramme 3.1: Promote eco-design and eco-processes**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| **Industrial Systems** | **1** | High value manufacturing integrating eco- design | Plastics<br>Textiles<br>Electronics and ICT |
| **Biomass and Biotechnologies** | **3** | Biorefinery process optimisation and integration towards circularity | |
| **Chemicals** | **2** | Prioritise chemical footprinting in product innovations | |
| | **3** | Hazardous chemicals substitution especially in the fields of waterproof and oil-proof materials, preservatives and antimicrobials, plasticisers, protective surface treatments | |
| | **4** | Extended producer responsibility | |
| **Plastics** | **1** | Design for sustainable plastic consumption and smarter use | |
| | **4** | Biobased plastics in a circular system | |
| **Raw Materials** | **3** | Eco-design & eco-processes in product design and material use | |
| | **4** | Advanced remanufacturing processes for safe and efficient material recovery | |
| **Waste** | **1** | Setting up circular business models to extend product lifespan | |

**Subprogramme 3.2: Promote re-use, repair and remanufacturing**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| **Biomass and Biotechnologies** | **1** | Sustainable management of biomass feedstocks from co-products, side streams and residual streams | Plastics<br>Food, water and nutrients<br>Batteries and vehicles |
| **Food Waste** | **3** | Re-commercialisation of commercial and agricultural food waste | |
| **Plastics** | **1** | Design for sustainable plastic consumption and smarter use | Construction and buildings<br>Packaging<br>Textiles<br>Electronics and ICT |
| **Raw Materials** | **1** | Mapping & valorisation of secondary feedstock | |
| | **4** | Advanced remanufacturing processes for safe and efficient material recovery | |
| **Waste** | **2** | Improve product design to extend product's lifespan and to enable reuse and remanufacturing<br>Improve product robustness and reliability (with limited resource use). | |

**Objective 4: To reduce the carbon emissions of companies**

**Subprogramme 4.1: GHG accounting and management system (individual company*)**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Industrial Systems | 2 | Digitalisation and circular economy research and projects | Plastics<br>Food, water and nutrients<br>Batteries and vehicles<br>Construction and buildings<br>Packaging |
| Plastics | 2 | Traceability and information in the plastic value chain | |
| Raw Materials | 1 | Mapping & valorisation of secondary feedstock | |
| | 4 | Advanced remanufacturing processes for safe and efficient material recovery | |
| | 6 | Efficiently aggregating valuable materials in waste collection | |
| | 7 | Efficient and effective material detection & separation | |
| Waste | 5 | Innovations to accelerate recycling and secondary markets | |

**Subprogramme 4.2: Promoting secondary raw materials market and industry**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Industrial Systems | 2 | Digitalisation and circular economy research and projects | Plastics<br>Food, water and nutrients<br>Batteries and vehicles<br>Construction and buildings<br>Packaging<br>Textiles<br>Electronics and ICT |
| Plastics | 2 | Traceability and information in the plastic value chain | |
| Raw Materials | 1 | Mapping & valorisation of secondary feedstock | |
| | 4 | Advanced remanufacturing processes for safe and efficient material recovery | |
| | 6 | Efficiently aggregating valuable materials in waste collection | |
| | 7 | Efficient and effective material detection & separation | |
| | 8 | Safe and efficient product dismantling and sorting | |
| Waste | 5 | Innovations to accelerate recycling and secondary markets | |

**Subprogramme 4.3: Reduce the carbon/GHG emissions in industrial systems**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Biomass and Biotechnologies | 2 | Resource efficient biomass pre-treatments and conversion into competitive products and applications | Plastics<br>Food, water and nutrients<br>Batteries and vehicles<br>Construction and buildings<br>Packaging<br>Textiles<br>Electronics and ICT |
| | 3 | Biorefinery process optimisation and integration towards circularity | |
| Chemicals | 2 | Prioritise chemical footprinting in product innovations | |
| Industrial Systems | 3 | Biorefineries support | |
| Raw Materials | 2 | Efficient primary mining & resource assessment | |
| | 1 | Mapping & valorisation of secondary feedstock | |
| | 3 | Eco-design & eco-processes | |

## 3. Closing the Loop

**Objective 1: To ensure that the manufacturing partnerships in Horizon Europe focus on key priorities in circular economy**

**Subprogramme 1.1: Circular complex product design**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Biomass and Biotechnologies | 2 | Resource efficient biomass pre-treatments and conversion into competitive products and applications | Plastics<br>Food, water and nutrients<br>Construction and buildings<br>Textiles |
| Construction and Demoliton | 1 | Planning and design for re-use and recycling | |
| | 2 | Effective material recovery and decontamination techniques | |
| Raw Materials | 8 | Safe and efficient product dismantling and sorting | |
| Waste | 1 | Setting up circular business models to extend product lifespan | |
| | 3 | Reducing packaging, strengthening waste prevention and reducing returns | |
| | 4 | Advanced and safe waste treatment, sorting and collection for circularity | |

**Subprogramme 1.2: Circular business model strategies for complex products**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Value Chains | 1 | Product lifetime extension | Plastics<br>Food, water and nutrients<br>Textiles<br>Electronics and ICT |
| Food | 1 | Smart, sustainable and productive farming systems | |
| Raw Materials | 8 | Safe and efficient product dismantling and sorting | |
| Waste | 1 | Setting up circular business models to extend product lifespan | |

**Objective 2: To address toxic/hazardous substances to human and environmental health in the context of circular economy**

**Subprogramme 2.1: Circular design and technical development for human and environmental health**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Construction and Demoliton | 2 | Effective material recovery and decontamination techniques | Plastics<br>Textiles<br>Electronics and ICT |
| | 3 | Methodologies for assessment of (environmental) life cycle costs | |
| Food | 1 | Product lifetime extension | |
| Plastic | 1 | Smart, sustainable and productive farming systems | |
| | 2 | Traceability and information in the plastic value chain | |
| | 3 | Improve recycling technologies including chemical recycling | |
| Raw Materials | 8 | Safe and efficient product dismantling and sorting | |
| Waste | 4 | Advanced and safe waste treatment, sorting and collection for circularity | |

**Subprogramme 2.2: Circular business model for human and environmental health**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Value Chain | 3 | Sustainable sourcing | Plastics<br>Food, water and nutrients<br>Batteries and vehicles<br>Construction and buildings<br>Packaging<br>Textiles<br>Electronics and ICT |
| Chemicals | 2 | Prioritise chemical footprinting in product innovations | |
| | 4 | Extended producer responsibility | |
| Plastic | 1 | Design for sustainable plastic consumption and smarter use | |
| | 2 | Traceability and information in the plastic value chain | |

**Objective 3: To elaborate and stimulate the adoption of new policies, standard and protocols for governance resource management systems, fostering inter-stakeholder collaboration and integrated management in the entire value chain**

### Subprogramme 3.1: Traceability and management of raw materials

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| **Value Chain** | **2** | Sustainable public procurement | Plastics<br>Batteries and vehicles<br>Construction and buildings<br>Textiles<br>Electronics and ICT |
| **Plastic** | **2** | Traceability and information in the plastic value chain | |
| **Raw Materials** | **2** | Efficiently aggregating valuable materials in waste collection | |
| **Waste** | **5** | Innovations to accelerate recycling and secondary markets | |

### Subprogramme 3.2: Promoting market viable solutions for circular economy rationale for the programme

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| **Food** | **4** | General upscaling of market-friendly circular economy innovations in the food sector | Plastics<br>Food, water and nutrients<br>Textiles<br>Electronics and ICT |
| **Plastic** | **2** | Traceability and information in the plastic value chain | |
| **Raw Materials** | **1** | Mapping & valorisation of secondary feedstock | |
| | **3** | Efficiently aggregating valuable materials in waste collection | |
| **Waste** | **1** | Setting up circular business models to extend product lifespan | |
| | **5** | Innovations to accelerate recycling and secondary markets | |

## 4. Resource Efficiency on Territory and Sea

**Objective 1: To design and promote sustainable maritime transport**

**Subprogramme 1.1: Transition to a circular and sustainable shipping industry**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Territory and Sea | 1 | Remanufacturing for the shipping industry | Plastics<br>Electronics and ICT |

**Objective 2: To promote efficient resource use in ports and coastal areas with a long-term perspective**

**Subprogramme 2.1: Transition to integrated resource management approaches working at the territorial level with a holistic and circular perspective**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Territory and Sea | 2 | Integrated resource management approaches working at the territorial level with a holistic and circular perspective | Plastics<br>Food, water and nutrients |

**Subprogramme 2.2: Transition to a sustainable fishing and circular aquaculture sector**

The innovation fields listed below form the basis of this subprogramme. The subprogramme also aligns with priority areas of the New EU Circular Economy Action Plan as listed below.

| Challenge or Theme | Innovation Field No. | Innovation Field Name | Relevant EU CEAP Priority Area(s) |
|---|---|---|---|
| Territory and Sea | 3 | Optimal fishing and aquaculture strategies | Food, water and nutrients |

## ANNEX III: Innovation fields excluded from the SRIA (on policy development and capacity building)

During the IF prioritisation stage, the SRIA team further reviewed the results and critically examined the IFs against the innovation focus of the future SRIA. It was decided that the SRIA should focus on technological and socioeconomic disciplines to promote circular economy innovation, and that IFs generally pointing towards policy development, capacity building and education would be more suitable as services on the programme owner platform. They were thus transferred to the team responsible for the platform in the CICERONE project.

### 1. IFs related to policy development

The IFs listed below are recommended for consideration by programme owners of the platform, in services and activities related to circular economy policy development and knowledge sharing.

| Challenge or Theme | Innovation Field |
|---|---|
| **Challenge Areas** | |
| Urban Areas | **Education and communication on circular services**<br>Develop educational programs for awareness and communication on circular economy |
| Industrial Systems | **Developing funding programs integrating CE concepts**<br>Developing funding programs which stronger focus on a systems integration by again integrating CE concepts into the funding programs of other strategic fields, such as Digitisation. Further support academic programmes related to industrial ecology, by funding and promoting them. Adjusting state aid rules to enable Member States to give state resources, where necessary, to EU companies in using new circular technologies and services. |
| | **Legislative initiatives and actions**<br>Implement a new product policy framework with legislative initiatives and actions |
| | **Producer Responsibility**<br>Further extend Producer Responsibility (EPR). |
| Value Chains | **Policy and organisational/process research**<br>To promote policy research to support policy makers, paying attention to influence from regional/local networking |
| | **Support to policy makers with tools and guidelines for encouraging circularity, i.e. end of waste criteria** |
| **Themes** | |
| Biomass and Biotechnologies | **Policy development to promote circular principles in bioeconomy**<br>Incentives are needed to increase the cascading use of biomass, valorisation of biomass, and capturing and utilisation of CO2 to produce value added materials and products. Policy (and instruments) mixes should be studied and developed which encourage investments in sustainable technologies. |

| | |
|---|---|
| Food | **Policy reform to promote circular economy practices in the agricultural sector**<br>A redesign is required of the Common Agricultural Policy with mandatory eco/ circular-economy schemes and financial targets for climate and environment spending. |
| Chemicals | **Public awareness and support to policy makers**<br>Increasing public awareness, also on the relationship between chemicals of concern and climate change to consumers, economists, politicians and policy makers. |

| Theme or Challenge | Innovation Field |
|---|---|
| Construction and Demolition | **Standardised processes and procedures for disassembly and selective demolition**<br>Establishment of standards and procedures for disassembly and selective demolition, aiming to maximise the reuse of building elements and the recycling of construction materials |
| Waste | **Political instruments to change behaviour**<br>▪ Improve the labelling (dynamic best-before date (e.g. fresh index) so that consumers do not throw away food before it is spoiled, App for determining the shelf life of foodstuffs)<br>▪ Developing criteria for circularity (eco-labels) and establish a uniform method e.g., for governments in sustainable public procurement<br>▪ Enabling the sharing economy, servitisation (the changing face of service and manufacturing in fashion), and proof on concepts of new, performance-based business models even in the absence of new technologies |
| | **Research on financial incentives**<br>▪ Calculate financial incentives: based on external impacts, calculate financial incentives needed to induce behavioural change. I.e. create standard calculation schemes for levies, fees, taxes or premiums for a specific product or service based on its external impact.<br>▪ Research on calculating the external impacts along multiple lifecycles for all end products and developing a user-friendly tool to do this as part of the design process, ideally using existing tools where available, such as the Sustainable Apparel Coalition's Higg Index for textiles.<br>▪ For impacts that cannot be quantified by a life cycle assessment or similar method, such as microplastics release, levies triggered by political action should accelerate change, such as the €0.15 plastic bag levy. |
| | **Political instruments to reduce waste**<br>▪ Political incentives to extend product's lifespan. Explore strategies against obsolescence (Consumer Sales Directive, Ecodesign Directive).<br>▪ Development of political regulations and mandatory standards for waste treatment (WEEE, ELV) to avoid wrong management and environmental damages.<br>▪ Develop clear definition of end-of-waste criteria and related update of permits for waste treatment operators to enable recycling of recyclable output fractions. |

| | |
|---|---|
| Water | **Regulatory reform to support integrated water management**<br>Development of regulatory framework to support the use of alternative water sources, elaborate policies and protocols for water management and improve efficiency in administrative procedures for reusing water in industry and agriculture. |

## 2. IFs related to education and capacity building

The IFs listed below are recommended for consideration by programme owners of the platform, in services and activities related to capacity building and knowledge sharing on circular economy.

| Challenge or Theme | Innovation Field |
|---|---|
| **Challenge Areas** | |
| Industrial Systems | **CE dedicated training programmes**<br>Integrate ecological themes such as the circular economy into vocational training programmes for digitisation and digital innovation Understanding the role of digitisation/ICT (particularly digital innovation hubs) for accelerating shared learning and implementation of circular strategies in different sectors. Offering vocational training programs on this topic for experienced professionals in decision-making positions. |
| Value Chains | **Education**<br>Creation of awareness campaigns and educational program at various level, as well as dedicated incentives mechanism |
| **Themes** | |
| Chemicals | **Sharing platform and education**<br>To foster sharing platform for increasing network building as objective or condition in funded projects and scoping phase with stakeholders before technical research and improve education through extracurricular activities, challenges and competitions, bootcamps, educational networks as start of a process of internalising safe-by-design in education and skills development |
| Construction and Demolition | **Education & training**<br>Dedicated training on sustainable buildings and building materials at universities and companies |
| Food | **Capacity building and education on agriculture**<br>Short term and long-term training on sustainable and circular food production and waste reduction to rural and urban farmers and in schools, extending to gardening activities in schools to raise awareness and knowledge amongst children and youth. |
| Waste | **Information & education in waste prevention**<br>Strengthening waste prevention initiatives by establishing dialogues and networking between political and social actors. Building reflexes for the younger generation using levers "learning by doing". Reducing returns (raising consumer and trade awareness for the negative effects of returns and provide alternatives). Innovation in design education towards waste prevention. |

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**CICERONE** aims to bring national, regional and local governments together to jointly tackle the circular economy transition needed to reach net-zero carbon emissions and meet the targets set in the Paris Agreement and EU Green Deal. This document represents one of the key outcomes of the project: a Strategic Research & Innovation Agenda (SRIA) for Europe, to support owners and funders of circular economy programmes in aligning priorities and approaching the circular economy transition in a systemic way.

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