ROADMAP FOR SUPPORTING POLICIES THROUGH **LIFE CYCLE APPROACH**

LCA4Regions is a European project, funded under the Interreg Europe programme, expected to contribute to the more effective implementation of environmental policy instruments by the application of Life Cycle Methodologies.

Since August 2019, **nine partners from 7 different regions across Europe** – Government of Navarra (ES), Industrial Association of Navarra (ES), Kaunas University of Technology (LT), Pyhäjärvi Institute (FI), Baixo Alentejo Intermunicipal Community (PT), Lombardy Region (IT), National Institute of Chemistry (SI), Lodzkie Region (PL), and ACR+ (BE) as advisory partner – are cooperating in this four-year project.
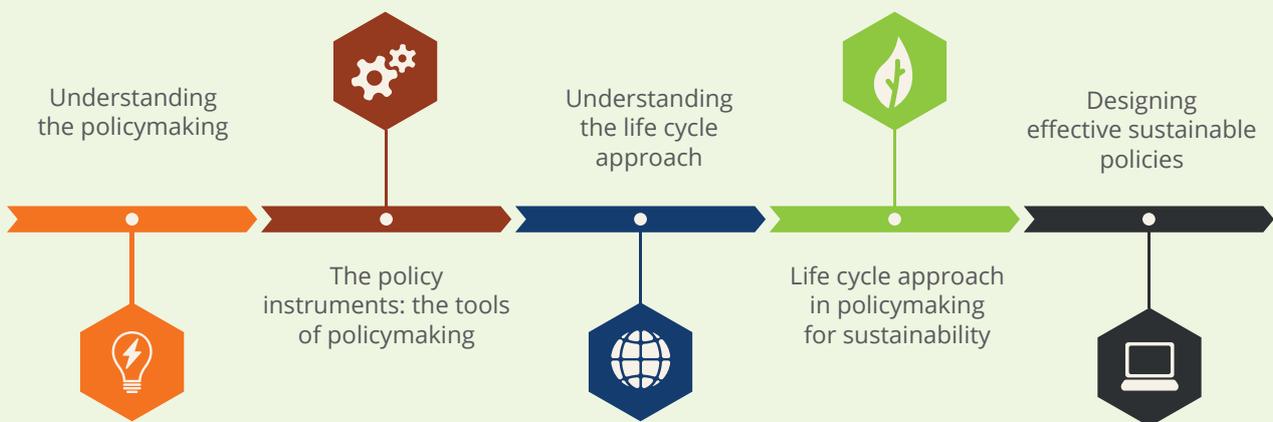
TABLE OF CONTENTS

A Roadmap to steer **the use of life cycle into policies**

Understanding the policymaking

The policy instruments: the tools of policymaking

Understanding the life cycle approach

Life cycle approach in policymaking for sustainability

Designing effective sustainable policies

1 Introduction

This roadmap aims to support policy makers to get a better understanding of the life cycle approach and how to integrate it effectively in policymaking processes.

This roadmap intends to be a policy brief to support the policy makers in addressing sustainability objectives through their policies, in particular applying life cycle-based tools and using a life cycle thinking mindset.

It is the result both of the experiences gained by the partners during the Interreg Europe LCA4Regions project activities and of the knowledge they already had as institutions.

The reader will notice that in some parts of this document we focus mainly on topics related to resource efficiency and circular economy. This is mostly due to the specific perspective we had in the project. Yet, the same approach can be applied to pursue other sustainability goals.

Approaching policies using a life cycle thinking mindset can really boost global and local sustainability. The life cycle thinking mindset used since the earliest stages of the policymaking (either in development policies or in sectorial and sustainability policies) is the best approach to create a great sustainability impact.

As we said, in this roadmap we intend to support the reader in understanding how to improve policymaking processes through life cycle thinking approach. Therefore, the first two sections of this document aim to consolidate common definitions and knowledge of a) Policies and policymaking processes and b)Life cycle approach(es).

2 Policies and policymaking

First of all, before describing and understanding the life cycle approach and its usefulness, we have to define and to scope the activities where we intend to use that approach.

The ground of our exploration are policies and the policymaking.

2.1 Definitions

A policy is a set of ideas or plans that is used as a basis for making decisions, especially in politics, economics, or business. Some other good definitions of policy can be found and proposed here:

• "a definite course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions" (see https://www.merriam-webster.com/dictionary/policy).
• "a high-level overall plan embracing the general goals and acceptable procedures especially of a governmental body" (see https://www.merriam-webster.com/dictionary/policy).

Then, several definitions are available of policymaking. The key reference for a definition of "policymaking" given by the EU is set by the documents "Quality of Public Administration - A Toolbox for Practitioners", Luxembourg: Publications Office of the European Union, 2017 and the "Better regulation guidelines", Brussels, 3.11.2021, SWD(2021) 305 final. There, policymaking is defined as "the process by which governments translate their political vision into programmes and actions to deliver 'outcomes' - desired change in the real world".

Another common and good definition of policymaking can also be "The decision process by which individuals, groups or institutions establish policies pertaining to plans, programs or procedures." (see: https://www.definitions.net).

2.2 In practice

This roadmap addresses public institution's policies and policymaking and how to integrate life cycle approaches into such processes.

A public body, whether it is the EU, or the government of a country, of a region or of a municipality, can pursue and carry out its policymaking processes through different kind of policy tools: a law, a regulation, a decree, a programme, a plan and should also be able to deal with all the subjects involved at a higher and lower institutional scale and with the pertinent stakeholders to produce an effective policymaking and policy implementation.

Moreover, public bodies must be able to use different policy tools in their policymaking, coordinating and fine tuning them, in order to support the achievement of the policy objectives.

For the sake of clarity, below we propose some examples: the EU level and the regional level.

2.2.1 The EU

Our source of information for this chapter is https://ec.europa.eu/info/law/law-making-process/types-eu-law_en.

Every action taken by the EU is founded on the treaties. These binding agreements between EU member countries set out EU objectives, rules for EU institutions, how decisions are made and the relationship between the EU and its members.

Treaties are the starting point for EU law and are known in the EU as primary law.

The body of law that comes from the principles and objectives of the treaties is known as secondary law.

The EU can pass laws only in those areas where its members have authorised it to do so, via the EU treaties.

A European act can be legislative or non-legislative: legislative acts are adopted following one of the legislative procedures set out in the EU treaties (ordinary or special); non-legislative acts do not follow these procedures and can be adopted by EU institutions according to specific rules.

The types of EU legal acts are: EU treaties; Regulations; Directives; Decisions; Recommendations; Opinions; Delegated acts; Implementing acts.

A quick dive into life cycle approach
The European Union can pursue a policy objective using a set of the above-mentioned policy tools.

As we are going to see in chapter 4.2, the life cycle approach can be used for supporting the definition of policies and their implementation and to help the definition of the policy tools described above.

An example of application of life cycle approach in EU policies is represented by the Regulation (EU) 2020/852 on Sustainable Finance Taxonomy, published on the Official Journal of the European Union on June 22nd, 2020 an entered into force on July 12th, 2020. The Taxonomy is a tool for the financial sector but includes references to scientific robust methods and metrics: among these, it is highlighted that climate mitigation thresholds are based, for sectors having sufficient data availability, on a full life cycle carbon footprint. For instance, for electricity production the Taxonomy defines the threshold of 100 gCO_2e/kWh. In other cases, e.g. for buildings and transport, thresholds have been defined considering only the life cycle phases contributing to most of environmental impacts (generally the use phase). To conclude, for all sectors "do not significant harm" criteria based on other environmental objectives and compliance with European legislation are included.

Another relevant example is constituted by Directive 2009/125/EC and s.m.i. on ecodesign requirements for energy-related products. In the Directive, "Ecodesign" is intended as the integration of environmental aspects into product design with the aim of improving the environmental performance of the product throughout its whole life cycle. Moreover, it is requested to manufacturers of products to perform an assessment of the product model throughout its lifecycle, based upon realistic assumptions about normal conditions and purposes of use, in order to address the environmental impacts that can be reduced through product design.

2.2.2 The regional context

In the European Union each Member State set its own relationships among central, regional and local government. Therefore, the legislative and executive power can be differently distributed in each country.

However, we will highlight some transversal considerations, which can be considered generally valuable for policy makers approaching this roadmap.

Focusing on the regional level, the policymaking action of a regional institution can be run and carried out through many kinds of policy instruments, which can be related one the other and under a hierarchical relationship. With the term "hierarchical" we mean that the kind of policy instrument can range from a law (the highest level) to an implementation act, which realises what a law or a plan foresee.

Below, a reference model of policy hierarchy is proposed. It is based on Regione Lombardia experience but probably suitable for a wide range of European Regions. A specific and more precise model can be developed by each interested region, to support its action on life cycle in a stronger and more effective way.

A quick dive into life cycle approach
As we are going to see in chapter 4.4, the support and the application of life cycle approach in policy instruments can be different, depending on the kind of policy instrument where it is intended to be used and its position in

TYPE OF POLICY INSTRUMENT	BODY RESPONSIBLE FOR IT	SCOPE
Regional law	It is approved by the Regional Council.	The contents can be: policy directions, principles, aims, financial resources, competences.
Regional regulation	It is approved by the Regional Council or by the Regional Government	The contents are: methods and tools for implementing a law (e.g. funding methods).
Plan or programme	It is approved by the Regional Council or by the Regional Government (as foreseen by the law).	The contents are: objectives, evaluations of current state of affairs, actions, monitoring.
Resolution	It is approved by the Regional Government.	The contents are: law enforcement mechanisms; guidelines; approval of tender criteria (later implemented by decree); breakdown of loans; promotion and approval of agreements with other institutions, etc.
Decree	It is approved by Director or Executive.	The contents are: technical clarifications; project approval; approval of calls; resource distribution.

the hierarchy. Moreover, to assure an effective use of life cycle approach to steer and support policy instruments, different actions in different policy instruments could be needed.

In this regard, the most relevant example is constituted by the set of Good Practices collected within the LCA4Regions project, which in most cases are regional policies and acts applying life cycle thinking and are available on the project website (https://www.interregeurope.eu/lca4regions/good-practices/).

For instance, a potential use of life cycle thinking in regional policies is green public procurement (GPP), which can implement rules for the selection of products characterized - for a given technical specification - by the minimum cost not only for the initial purchase but also for the operation of the product and its end-of-life. This is an example of life cycle costing applied to public procurement, and has been implemented e.g. by the Public Procurement Agency in Slovenia for road vehicles, whose award criteria include the operational lifetime costs calculated according to a specific formula.

Another potential use of LCA in regional policies is constituted by the action implemented by Regione Lombardia in the definition of its waste management programme, which includes a LCA study of the baseline situation in terms of waste management adopted in the Region since 2009, with the aim to evaluate the main sources of environmental impact in the life cycle and identify reduction opportunities.

2.3 Sustainability into policies

LCA and sustainability in general have many potential applications within public policy development because of the common desire for policy to reduce environmental impacts, and the resulting need to identify opportunities for environmental improvement and assess environmental tradeoffs between potential options.

Institutions at different hierarchical levels design and implement policies and use the policy instruments available under their responsibility to pursue the objectives set in the policies.

At the beginning the policy action was mainly sectorial and aimed at achieving specific and focused objectives or cross cutting development objectives.

As time goes by, the awareness that a policy can produce spill-over effects and, in particular, considering the majority of the policies were aimed at boosting development, those policies can have social and environmental impacts, globally and locally: humankind understood that any action and policy can have externalities.

That's why international, national and local institutions started developing sectorial policies to protect society and environment.

Little by little, we understood that the only way both to design sound policies and to manage environmental and social externalities, was to move our mindset toward a policy design process which allows to understand their whole impact and the integration of externalities into the policymaking, considering together economic, environmental and social variables in the decision and policymaking: the sustainable development concept came up.

Environmental impact assessment and strategical environmental assessment were the first attempts to use integrated analysis to make the human action sustainable from an environmental point of view. Integrated pollution prevention and control (IPPC) policies, social and environmental certification for organisation and integrated product policies were further steps of this journey. This is the ground on which a growing trend towards integration of life cycle approach and thinking into policymaking processes has flourished.

Then and in the meanwhile many other tools were designed to consider also social aspects and to run evaluations always more integrated.

Along the time, the humankind's actions and policies are moving toward their overall sustainability.

Nowadays, the global challenges and the most advanced policy approaches (UN 2030 Agenda, EU Green deal, etc.) are driving the world in considering sustainability as something to be taken into consideration in all the sectorial policies, supported by the belief that a real sustainable future can be guaranteed only if sustainability in all its 3 components (social, economic, environmental) permeates all the policies.

The life cycle approach can be considered as one of the most fitting methodologies to deal with sustainability. It is indeed interesting to evaluate how Life Cycle Assessment is different from Environmental Impact Assessment: EIA only accounts for emissions and effects occurring at the project location, whereas LCA considers all environmental impacts related to the process or product across its life cycle, wherever they are located.

Sustainability policies (environmental and social specific policies) and development policies can benefit from life cycle approach.

In particular, it must be stressed here that the life cycle thinking is going to be especially important in framing development policies, because these often create the greatest sustainability impacts (both good and bad).

3 The life cycle approach

3.1 An overview

This roadmap wants to be first a concrete and grounded document. We intend to provide the policy makers with tools useful to support the design of policies coherent with the sustainable development goals, capable of defining choices, which are aware of the effects produced by them and to avoid, mitigate or compensate their spill-over and impacts.

In the wide range of tools usable for these purposes, the Life cycle approach, the life cycle-based tools seemed to be the most suitable for this aim and the whole project decide to focus on them as tools for supporting sustainability.

Therefore, the present roadmap focuses on them, while being aware that other tools could be used to support sustainability objectives, sometimes integrated with life cycle-based tools.

The European Commission stressed the importance of these tools to address sustainable choices and has been using them in its policymaking.

Several steps have been taken so far at national level, in EU countries, to stimulate the use of and to apply these tools.

After an overview of the main Life cycle-based concepts and tools, in this chapter we also provide an overview of the international, European references and experiences on the life cycle approach.

We think this overview can provide the readers with some useful references and key-aspects to guide their mindset towards the right understanding of how to use life cycle thinking approach in policymaking.

In the following paragraphs, a description of the key-concepts, the most common methodologies and tools related to life cycle approach is presented.

The aim is to provide the readers with a clear even if concise overview, so as to facilitate readers in choosing the most appropriate tools for their needs.

3.2 LC for sustainability: life cycle sustainability assessment

Life cycle thinking, due to its systemic approach, is considered to provide a valuable support in integrating sustainability into design, innovation and evaluation of products and services. The life cycle approach and its methodologies can be a good set of tools for sustainability.

"While LCA focuses primarily on burdens linked to emissions into the environment and resources, life cycle costing (LCC) aims at assessing cost along the supply chain and the emerging Social life cycle assessment (SLCA) complements this in relation to working hours/conditions to more complete the environment and socio-economic analysis. Aiming to cover the different pillars of sustainability, life cycle sustainability assessment (LCSA) methodologies and applications are under development aiming at integrating better sustainability pillars, assessing the mutual interaction amongst them. […]".

With the wording reported above the JRC Technical report "Life cycle assessment for the impact assessment of policies (2016)" proposes a full use of life cycle tools to address sustainability, as the image below clearly summarises.
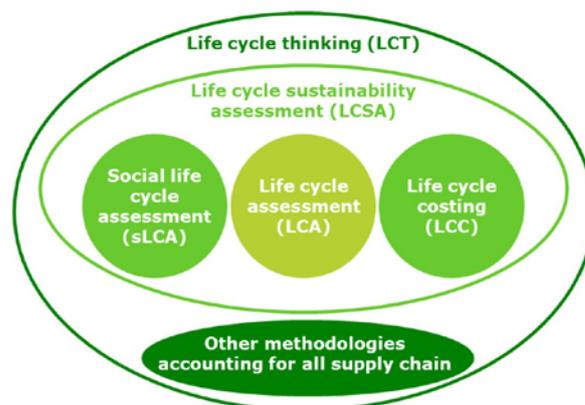
Figure 1: European Commission Joint Research Centre

3.3 Life cycle thinking

The life cycle thinking is the crucial concept in the life cycle approach.

We rely on the definition and the reasoning provided by the Life Cycle Initiative (https://www.lifecycleinitiative.org/), to give the reader a clear understanding of it.

"Life Cycle Thinking is a mostly qualitative discussion to identify stages of the life cycle and/or the potential environmental impacts of greatest significance e.g. for use in a design brief or in an introductory discussion of policy measures. The greatest benefit is that it helps focus consideration of the full life cycle

of the product or system; data are typically qualitative (statements) or very general and available-by-heart quantitative data. (Christiansen et al., 1997)

Life Cycle Thinking (LCT) is about going beyond the traditional focus on production site and manufacturing processes to include environmental, social and economic impacts of a product over its entire life cycle.

The main goals of LCT are to reduce a product's resource use and emissions to the environment as well as improve its socio-economic performance through its life cycle. This may facilitate links between the economic, social and environmental dimensions within an organization and through its entire value chain.

Looking at the industrial sector, taking LCT as an approach means going beyond the more narrow traditional focus on an enterprise's production facility. A product life cycle can begin with the extraction of raw materials from natural resources in the ground and the energy generation. Materials and energy are then part of production, packaging, distribution, use, maintenance, and eventually recycling, reuse, recovery or final disposal. In each life cycle stage there is the potential to reduce resource consumption and improve the performance of products."

For our purposes, we should just switch form products and systems to policies.

3.4 Life cycle assessment tools and methods

The present section lists and describes the main tools and methods that can be adopted for life cycle assessment, which have the peculiarity of generating information, understanding and quantification of life cycle impacts.

Life cycle assessment LCA (materials, energy)
Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle. (ISO 14040).

Carbon footprint (CF)
A total product carbon footprint is a measure of the direct and indirect greenhouse gas (GHG) emissions associated with all activities in the product's life cycle. Products can be both goods and services. (UNEP/SETAC, 2009).

Materials flow assessment (MFA)
Systematic assessment of the flows and stocks of materials within a system defined in space and time. (Brunner and Rechberger, 2004).

Environmentally extended input-output tables (EEIO)
The data presented by national statistical agencies as supply-use tables (also known as "make-use tables") and direct requirements tables. The environmental extension is an inventory of the elementary flows for each unit process in these tables. (Life Cycle Innitiative).

Social life cycle assessment (S-LCA)
A social and socio-economic life cycle assessment (S-LCA) is a social impact (real and potential impacts) assessment technique that aims to assess the social and socio-economic aspects of products and their positive and negative impacts along their life cycle. (UNEP/SETAC, 2009).

Life cycle sustainability assessment (LCSA**)
Refers to the evaluation of all environmental, social and economic negative impacts and benefits in decision making processes towards more sustainable products throughout their life cycle. (UNEP/SETAC, 2011)

Organizational LCA (O-LCA**)
Compilation and evaluation of the inputs, outputs and potential environmental impacts of the activities associated with the organization adopting a life cycle perspective. (ISO/TS 14072).

Life cycle costing (LCC)
Compilation and assessment of all costs related to a product, over its entire life cycle, from production to use, maintenance and disposal. (UNEP/SETAC, 2009)

3.5 Life cycle management tools

According to UNEP/SETAC Life Cycle Initiative – LCM programme, life cycle management is "an integrated framework for managing the total Life Cycle performance of goods and services towards more sustainable forms of production and consumption. It comprises both existing analyses (analytical tools, checklists, methods and techniques) and practice (policy/corporate programs, policy/corporate instruments, and procedural tools), and provides an opportunity for proactively managing the economic, social and environmental performance of products and services in an integrated manner".

This paragraph focuses on the description of the main tools that can be adopted for life cycle management. It is not an exhaustive list, but includes those identified in the LCA4Regions Good Practices.

Eco-design
Systematic approach, which considers environmental aspects in design and development with the aim to reduce adverse environmental impacts throughout the life cycle of a product. (ISO 14006).

Eco-labels
Label that indicates the overall environmental preference of a product within a product category, over life cycle considerations. (ISO 14024).

Environmental Product Declarations (EPD)
Environmental declaration providing quantified environmental data using predetermined parameters, and where appropriate, additional environmental information. (ISO 14025).

Product Environmental Footprint (PEF)
It is the European Union recommended Life Cycle Assessment based method to quantify the environmental impacts of products (goods or services). (Commission Recommendations 2013/179/EU).

Product-service system (PSS)
It is a competitive system of products, services, supporting networks and infrastructure. The system includes product maintenance, parts recycling and eventual product replacement, which satisfy customer needs competitively and with lower environmental impact over the life cycle. (UNEP).

Circular/ Sustainable Materials Management (SSM)
Sustainable materials management (SMM) is a systematic approach to using and reusing materials more productively over their entire life cycles. (UNEP).

Circular public procurement (CPP)
The process by which public authorities purchase works, goods or services that seek to contribute to closed energy and material loops within supply chains, whilst minimising, and in the best case avoiding, negative environmental impacts and waste creation across their whole life cycle. (European Commission).

Sustainable public procurement (SPP)
A process whereby public sector organisations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole life basis in terms of generating benefits not only to the organisation, but also to society and the economy, whilst minimizing, and if possible, avoiding, damage to the environment.

Green Purchasing (GP)
A process whereby public authorities seek to procure goods, services and works with a reduced envi-ronmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured. (Communication (COM (2008) 400)).

Sustainability reporting
Organization's practice of reporting publicly on its economic, environmental, and/or social impacts, and hence its contributions – positive or negative – towards the goal of sustainable development. (Global Reporting Initiative (GRI)).

3.6 Life cycle toolbox

All in all, we can sum up and include all the tools related to the implementation of the life cycle approach in a common framework, the Life Cycle toolbox, which can become a useful reference for the reader to understand more easily the range of methodologies that can be applied depending on circumstances and the needs. It is proposed below.

Selected Life Cycle Tools, Procedures and Concepts useful for efficient and effective implementation of SDGs

Life cycle systems and concepts
Circular economy
Industrial ecology
Product-service system
Cradle to grave/cradle to cradle
Environment/sustainability footprints

Action tools based on LCA
Eco-Labels*
Environmental Product Declarations (EPD)*
Product environmental footprint (PEF)*
Eco-design

Life cycle assessment tools and methods
Life cycle assessment LCA* (materials, energy)
Materials flow assessments (MFA)
Input-Output tables
Social LCA (SLCA)
Sustainability LCA
Orgnisational LCA (O-LCA)
Life cycle Costing (LCC)
Chemicals assessment*
Risk assessments
Evolving assessment tools for biodiversity, LULUC, landscape, etc.

Life cycle management tools
Sustainable supply-chain management (SSCM)
Circular materials management
Sustainable and/or circular public procurement (SSP,CCP)
Green purchasing (GP)
Extended Producer Responsability (EPR)
Environmental Management Systems* (EMS, EMAS)
Sustainability reporting* (e.g. GRI)

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1. Some of the above have been standardized procedures under international agreements or practices*
2. Other concepts such as sustainable production, resource efficiency, etc, also provide useful frameworks for implementing selected SDGs

4 Life cycle and policies

As we have to support the policy maker in using the life cycle approach and taking into consideration the policy maker will use it in a scenario where the framework, the action space, is defined by the UN, EU and the national and local references, in this chapter we propose an overview and some hints with respect to those four levels.

4.1 The life cycle approach at international level

The most interesting international reference in the field is the Life Cycle Initiative, which is a public-private, multi-stakeholder partnership enabling the global use of credible life cycle knowledge by private and public decision makers. It is hosted by UN Environment and it is at the interface between users and experts of Life Cycle approaches. It provides a global forum to ensure a science-based, consensus-building process to support decisions and policies towards the shared vision of sustainability as a public good. It delivers authoritative opinion on sound tools and approaches by engaging its multi-stakeholder partnership (including governments, businesses, scientific and civil society organizations). The Initiative facilitates the application of life cycle knowledge in the global sustainable development agenda in order to achieve global goals faster and more efficiently.

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At the heart of the Agenda there are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all Countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.

It is therefore interesting to investigate the existing correlations between the SDG and life cycle approach. This has also be done by the Life Cycle Initiative in 2020, in the study "LCA-based assessment of the Sustainable Development Goals". In this study focus is set on the impacts on sustainable development caused by human pressures, which correspond to elementary flows resulting from LCA. Categories of indicators for the LCA-SDG assessment are defined, which are economic, environmental and social. For instance, the LCA-SDG assessment for the field of clean water and sanitation is presented in the following figure. The execution of such an analysis can allow identifying logical correlations of policies implemented in one or more of the SDG focus areas.
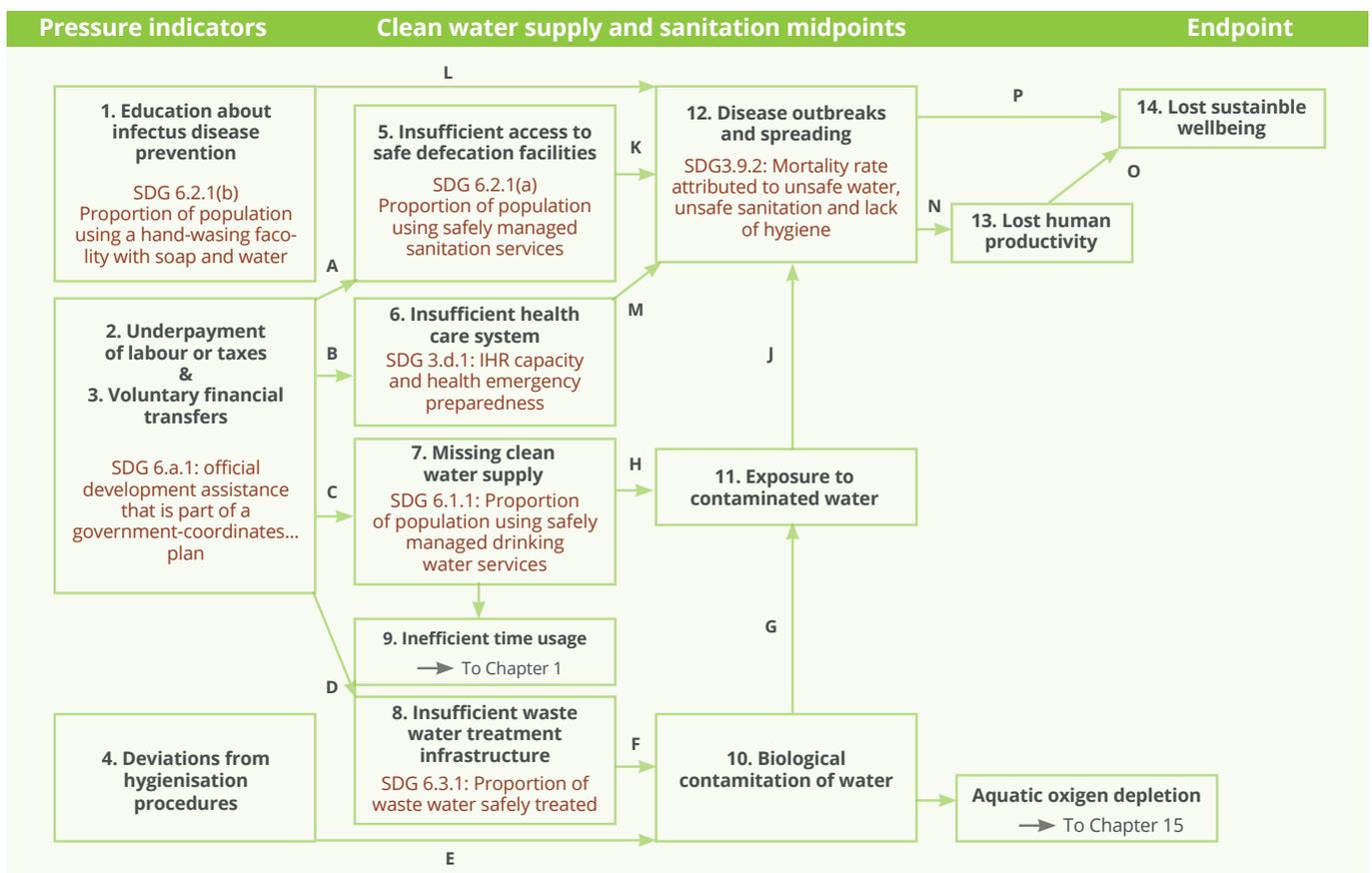
Figure 2: Life Cycle Initiative, 2020: LCA-based assessment of the Sustainable Development Goals" study.

4.2 The life cycle approach at European level

What we want to emphasise in this paragraph is the particular role the European Commission confers to the life cycle approach in supporting policymaking and in carrying out the impact assessment of the policies.

The reasoning proposed allows us to understand what is the right approach to be followed to define how to use Life cycle to support the achievement of our policy goals.

The reference document for this paragraph is "Sala S., Reale F., Cristobal-Garcia J., Marelli L., Pant R. (2016), Life cycle assessment for the impact assessment of policies, EUR 28380 EN; doi:10.2788/318544".

At the end of this chapter readers will find a section extracted from that document, because we think that wording is particularly inspiring for our aims.

Life cycle approach in the policy cycle
One of the key points of the EU policymaking is to develop evidence-based regulations. The European Commission assesses the impact of policies, legislation, trade agreements and other measures at every stage - from planning to implementation and review - in order to ensure that EU action is effective. This is the principle of the so called smart regulation.

The typical policy cycle - underpinning the development of a new policy - presents a number of steps, listed below:
• Policy anticipation and problem definition: identifying problems that require government attention, deciding which issues deserve the most attention and defining the nature of the problem;
• Policy formulation: definition of policy options in terms of means and possibilities to achieve policy objectives;
• Policy impact assessment: evaluation of the environmental, social and economic impacts of the different policy options in order to identify the one that maximize benefits reducing impacts;
• Policy implementation: actual application of what is prescribed by the selected policy option;
• Policy evaluation: assessment of the effectiveness of the policy.

Since 2003, with the first Inter Institutional Agreement on better law-making, the European Parliament, the Council of the European Union (EU) and the Commission have agreed on the overall aim to optimize the drafting and implementation of the Union law.

Thanks to this Agreement, the pre-legislative consultations and impact assessment in the draft legislation are become an essential part of the policymaking process.

The objectives identified by the above-mentioned agreement, have been strengthened and widened by the Smart Regulation in the European Union reporting as first key message "smart regulation is about the whole policy cycle – from the design of legislation, to implementation, enforcement, evaluation and revision". The role of impact assessment in the new legislation is recognized as well as the relevance of similar efforts in the management and implementation of existing legislation in order to ensure that it delivers the intended benefits.

Finally, in the communication "Better rules for better results – An EU Agenda" new "Integrated Guidelines on Better Regulation" are provided by the Commission in order to better support the policymaking process and ensure that environmental, social and economic aspects are properly taken into account at each stage.

Moreover, the need of maximising the science to policy interface towards evidence-based regulations is clearly stated. To this aim a Better Regulation toolbox is provided. In this context, an important role is recognized to the LCA, which is included in the Better Regulation Toolbox as tool number 583.

In each step of the policy development, LCA could be applied for different purposes, from problem identification up to policy evaluation.
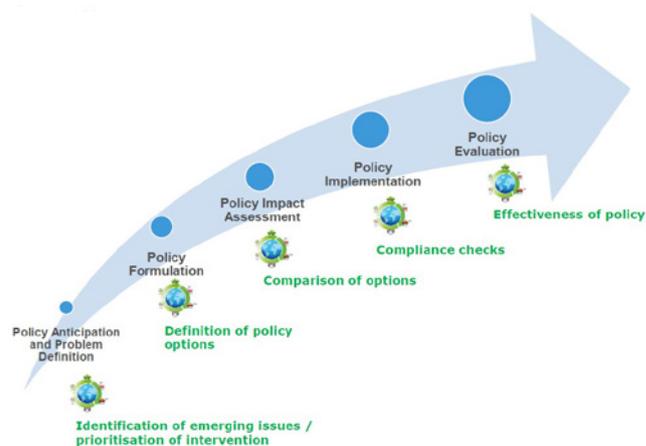

Figure 3: European Commission Joint Research Centre

Indeed, life cycle assessment and life cycle-based methodologies could be integrated in the policy cycle to support answering several key questions. Considering steps in policy cycle and current practice, LCA may be useful in supporting policy in different ways as reported in the Table below.

Steps in the policy cycle	Related possible questions in the impact assessment	Description	Current and possible use of LCA
Policy anticipation and problem definition	What is the problem and why is it a problem?	Identification of emerging issues.	LCA studies in scientific and grey literature, reporting "warnings" to be taken into account
Policy formulation	What are the various ways to achieve the objectives?	Definition of policy options.	Policy options may: - Be based on LCA results (e.g. addressing a specific life cycle stage or relevant environmental impact, leading to impacts) to identify specific "hot spots". - Include some requirements based on LCA indicators (e.g. a life cycle based calculation). - Use LCA for identifying key elements to be monitored over time and, possibly, be standardize. - Use LCA results to set a target.
Policy impact assessment	What are their economic, social and environmental impacts and who will be affected? How do the different option s compare in terms of their benefits and costs?	Comparison of options	Supporting the comprehensive and systematic assessment of environmental aspects, and even beyond environmental aspects if including LCC and SLCA. LCA may spot impacts related to a number of different impact categories and may help avoiding shifting burden from one stage in the life cycle to another. Complementary to risk assessment.
Policy implementation		Country level implementation. Compliance checks.	If LCA indicators are used as requirements of the policy option, LCA studies will be needed.
Policy anticipation and problem definition	How will monitoring and retrospective evaluation be organized?	Effectiveness of the policy. Evaluation of the need to revise (or phase out) the policy.	Use of LCA for assessing the benefit of the policy (at macro scale) including systemic aspects. Need of modifying/ repealing a legislation.

Details from "Life cycle assessment for the impact assessment of policies", Sala, S., Reale, F., Cristobal-Garcia J., Marelli, L., Pant R.- Chapter 3

Regarding **policy anticipation and problem definition**, LCA studies may present insights and warnings to be taken into account with relations to products and supply chains. For example, LCA has been the basis for the problem definition of the life cycle impact assessment in the communication "Building single market for green product" (EC 2013a); LCA studies demonstrated how some methodological choices in the application of LCA can strongly affect results and hamper a fair comparison between similar products, thus highlighting the need for a harmonized assessment methodology. Or, in the case of the construction sector, a life cycle perspective to the environmental impacts occurring in buildings brought to the attention of policy-makers the need to include also indicators associated to the manufacturing stage in the framework of core indicators for the assessment of environmental performance of building.

As far as the **policy formulation** step is concerned, results from LCA studies could be used to orient policy options, e.g. suggesting an overall approach focused on a life cycle stage or on a Life cycle environmental impact. Moreover, environmental considerations based on LCT could suggest the adoption of requirements based on LCA indicators or support their identification, e.g. the calculation of emissions to air/soil/water or the total amount resources used throughout the life cycle (or for part of it). These requirements could be "generic", meaning that they do not establish a limit value but simply require for calculation, considering that the first step towards the improvement of environmental performances is the measurement. In other cases, LCA data could suggest a "specific" requirement, intended as a minimum performance level. Different requirements could be suggested/identified and used in the different policy options. LCA has been already used in the development of policy options.

In the same way and at large scale, in the policy formulation step the need to set a target to be reached could be recognized. Thus, an LCA study could be launched to identify possible range and suggest different target options. It is important to highlight that the use of LCA may be fundamental for robust targets setting, as through the application of LCA it is possible to: i) assess environmental performance of representative products, helping in contribution analysis in terms of most important impact categories and most relevant life cycle stages implying an impact, as basis for setting the target; ii) avoid burden shifting over impact categories (increasing impact in an impact category while reducing the impact on another respecting a fixed target)

and over life cycle stages (e.g. increasing impact in a life cycle stage when the target is focusing on another one); iii) run scenarios under specific assumptions in terms of production and consumption patterns to estimate impacts associated to possible future scenarios in which the target is achieved; iv) assess environmental impacts and benefits associated to the implementation of the targets (either as technological solution, behavioural change, infrastructural change).

The of use LCA to establish **a minimum performance level or a target** implies that LCA data have to be available and have to be of proper quality. The LCA community has been working for years in this direction promoting firstly, knowledge on LCA and LCA data sharing, secondly, further specifications for LCA application to specific products (Category Rules – CR), thirdly, data quality evaluation in relationship to specific requirements.

Regarding the step of the **policy impact assessment**, LCA may complement others methodology for evaluating environmental impacts. LCA may support the comprehensive and systematic assessment of environmental aspects, and even beyond environmental aspects if including Life Cycle Costing and Social LCA. Moreover, as previously said, LCA may spot impacts related to a number of different impact categories and may help avoiding burden shifting from one stage in the life cycle to another, assessing also future scenarios (De Camillis et al. 2013). In policy impact assessment, risk assessment approaches are usually adopted. The potential complementary to risk assessment is one of the key element for enhancing the use of LCA in the impact assessment step. As discussed by Cowell et al. 2002, a complementarity of RA and LCA is necessary to answer to different questions. Nonetheless, the two approaches differ on several aspects, including: philosophical approach; quantitative versus qualitative assessment; stakeholder participation; the nature of the results; and the usefulness of the results in relation to time and financial resource requirements, and comprehensibility of the results for non-specialists.

At this step of the policy cycle it is important to keep in mind that methodological choices can affect LCA results and, in turn, the outcome of options comparisons. Examples of key methodological aspects are the modelling approach and the LCIA method.

In relationship to the modelling approach, different visions exist. The ILCD Handbook recommends the use of a CLCA for those analysis intended to inform policymaking and ALCA in case no decision has to be taken (Plevin et al. 2014a). Some authors (Zamagni et al. 2012) argue that CLCA is more useful for examining alternative scenarios to understand the range

of potential environmental impacts rather than for predicting a single most-likely outcome. Some others (Plevin et al. 2014a) do not fully agree with the scheme proposed by the ILCD Handbook and recognize that the ALCA has a role (other than descriptive) in guiding normative considerations (how to equitably allocate impacts, costs and benefits), that it is useful as a diagnostic tool to perform sensitivity analysis and that it can reasonably provide information to aid in general decision making.

As far as the LCIA method is concerned, several LCIA methods exist, built on different LCIA models. In relation to this aspect, the ILCD Handbook (EC-JRC 2010-2012) provides method recommendations for the several impact categories; however, the study only 15 include LCIA methods available in 2008. Moreover, studies are being conducted about the need/convenience to revise the scope of the Areas of Protections (AoP) the impact categories relate to, e.g. for the AoP "Natural Resources" where new and more comprehensive perspectives concerning "what has to be safeguarded" have been delineated (Dewulf et al. 2015). LCIA methods have been recently revised and updating proposals have been made (Sala et al. 2016b), including this aspect too.

The use of the LCA in the **policy implementation** step depends on policy options. At general level, policy options may be based on LCT/LCA results and/or may include some requirements based on LCA indicators. If LCA indicators are used as requirements of the policy option, LCA studies will be needed. For example, a complete LCA study may be requested before putting a certain product on the market, addressing one or more impact categories (environmental criteria); an LCA could be used to verify the compliance of a product with a specific requirement (minimum performance level) ; more LCA studies could be required to implement or further specify policy aspects such as the setting of a benchmark (national or European) for a specific product/service categories or to identify relevant environmental indicators for performance assessment.

Finally, in the step of the **policy evaluation**, LCA may be used for assessing the benefit of the policy (at macro scale) including systemic aspects and for spotting specific needs for modifying/repealing a legislation. For the latest, an example of use of LCA is the repeal of waste oil directive based also on a study reporting LCA evidences (EC, 2001).

The publication, which was the source of this chapter, also propose an interesting summary of the main concrete use done by the EC of Life cycle tools in its polices.

We invite the reader to refer to that document to have a complete view of the research.

4.3 The national context

The policy makers should have a clear overview of the national legislative framework.

Actually, using life cycle to support policymaking at regional level requires, to be effective, the knowledge of the national legislative framework, to be aware of the opportunities and the barriers given by this system to the use of life cycle approach. Some European countries can have already developed pieces of legislation foreseeing the use of life cycle approach or supporting and pushing its use.

The awareness of this legislation is crucial to set a right use of life cycle in local policies. The life cycle use at local level has to comply with the national framework and can refer to it to strengthen its effectiveness.

4.4 The local-regional context

An institution is responsible for the design, the management and the implementation of a high number of policies, programmes and plans. As we have already mentioned, the policymaking action of a regional institution can be run and carried out through many kinds of policy instruments, which can be related one the other and under a hierarchical relationship. With the term "hierarchical", we mean that the kind of policy instrument can range from a law (the highest level) to an implementational act, which realises what a law or a plan foresee.

The support and the application of life cycle approach in policy instruments can be different, depending on the kind of policy instrument where it is intended to be used and its position in the hierarchy. Moreover, to assure an effective use of life cycle approach to steer and support policy instruments, different action in different policy instrument could be needed.

Therefore, LCA4Regions project points out the importance of carrying out an analysis of the typologies of policy instruments producible under the responsibility of the institutions and their hierarchical role in the local policymaking, LCA4regions focuses on the integration of life cycle approaches in policymaking processes at the local and regional level. In order to provide readers of this document with useful suggestions, this chapter is divided into three sections: Preliminary steps; Hierarchy and Examples.

4.4.1 What preliminary steps should local and regional authorities take to set a fertile ground for integration of life cycle thinking in policymaking?

1. Developing a cross-sector approach at the political and administrative level
Both on a city and regional level public authorities are usually splitting responsibilities for economic, social and

environmental issues between different services or administrations. For the purpose of addressing sustainable development, moving towards life cycle based approaches, it is needed a close cooperation between those services and administrations. Even when leaving the private sector out of the equation, under the responsibility of senior political representatives (mayors or their deputies, ministers, secretaries of state) there are many public organisations among which such transversality should be developed. The challenge of transversality could emerge even within the same administrative entity: for example, among different departments responsible for planning, legal assistance, public procurement, communication and or cartography, etc. Cross-sector and interdepartmental approaches within the public administration are needed to balance and link different policy tools and action as the ones highlighted in the figure 4.

Figure 4: ACR+

2. Promoting shared governance and engage potential stakeholders at early policymaking stages

To make this point more concrete, we can refer to local bioeconomy strategies, where experience in transition strategies demonstrated the value of a larger engagement of stakeholders than the triple helix (public administrations, businesses and research/academia) bringing in the loop civil society organisations (CSOs) that represent local communities, as well as representatives from the financial sector in a penta helix of stakeholders. The involvement of various professionals along different value chains is essential to design a broad yet relevant, ambitious yet realistic, globally-minded yet locally-centred strategy. Co-construction is key, both with external stakeholders but also within the internal layers and services of public administrations. This can be done using the intermediary of public consultations, the creation of a stakeholder platform, or the setting up of an advisory committee, amongst other things. It is up to public authorities to organise a balanced participation of

all these stakeholders, or even to coordinate and facilitate the creation of a "public-private forum", which would contribute to the cocreation of eco-innovative actions based on synergy and complementarity. In addition to such participative strategies, the territorial actors should also be able to access information on the available resources, as well as on their needs and those of their peers (e.g. by promoting contacts between producers and recyclers of product components). Such transparency requires a relationship based on trust and cooperation rather than competition. Here too, public authorities have a role to play, especially when it comes to facilitating the access to information or acting as an intermediary, given their neutral status with regards to sensitive information.
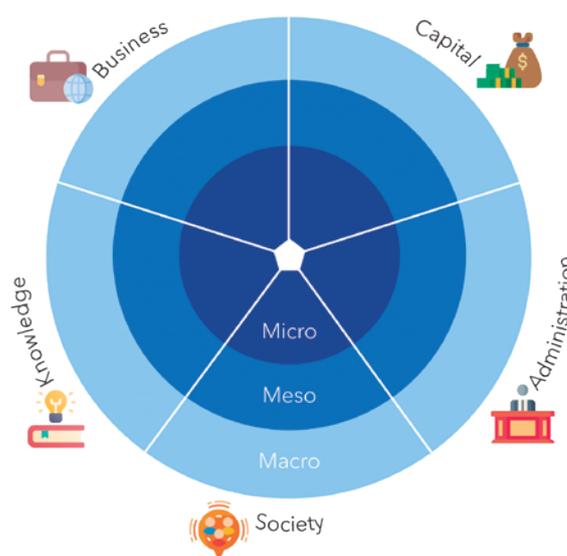
Figure 5: ACR+, adapted from Turas project

3. Coordinating and finding synergies between parallel policy actions in progress or planned

Diverse already-existing initiatives and policy instruments should be identified, as a base for strategic policymaking processes. Life cycle thinking foresees a strong attention on unwanted/spillover effects, thus it is particularly important to take into account the already existing strategic and operational plans which have a direct or indirect link with ongoing policymaking processes. Let's take the example of sustainable construction. When developing a sustainable construction strategy or specific policy actions, instruments of all types should be considered: legal (building permits for example), economic (landfill tax on soil and other materials, rebates), training, etc. Furthermore, many aspects should be addressed: health and well-being, environment (landscape, energy and materials efficiency), economy, community developments, education and skills, urban planning, local culture and tourism, etc. Including complementary instruments in the local strategy will definitely increase its chances of success.

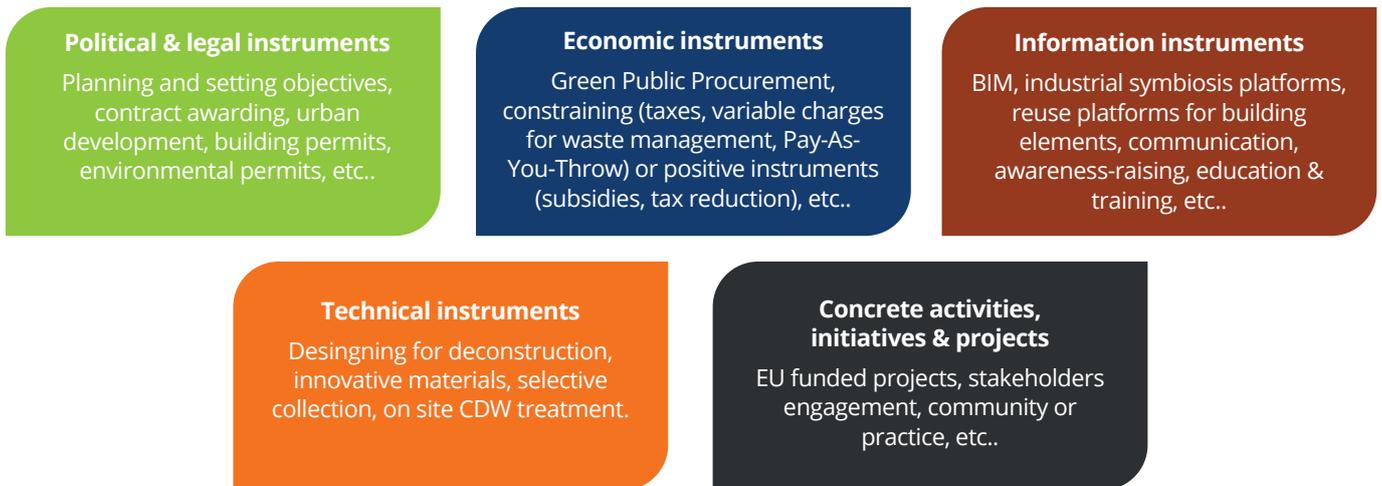| Political & legal instruments	Economic instruments	Information instruments
Planning and setting objectives, contract awarding, urban development, building permits, environmental permits, etc..	Green Public Procurement, constraining (taxes, variable charges for waste management, Pay-As-You-Throw) or positive instruments (subsidies, tax reduction), etc..	BIM, industrial symbiosis platforms, reuse platforms for building elements, communication, awareness-raising, education & training, etc..

Technical instruments	Concrete activities, initiatives & projects
Desingning for deconstruction, innovative materials, selective collection, on site CDW treatment.	EU funded projects, stakeholders engagement, community or practice, etc..

Figure 6: ACR+

4. Improving performance and assessment schemes

Here, we will keep referring to the construction value chain, as life cycle thinking approach has been widely used to assess the sustainability of products in the construction sector for several years. As an example, LCA results can be translated into Environmental Product Declarations (EPDs) for single products or Environmental System Declarations (ESDs) for kits. Existing and upcoming legislation in some Member States (for example France, the Netherlands, and Belgium) already refers to these LCA and EPD/ESD assessment methods. In addition, the European Committee for Standardisation is working to guarantee harmonized assessment methods for several standards to assess the sustainability of the buildings. In parallel, many countries have developed building assessment schemes (e.g. BREEAM, DGNB, HQE, LEED, SBtool, VERDE) over the last two decades. Adherence to standards helps to ensure that products are safe, interoperable and good for the environment. Harmonizing technical specifications of products and services can make industries more efficient and can break down barriers to trade. Even if the process to develop standards could be time consuming and complicated, public authorities must strive to set optimal standards ahead of regulation, so that it can shape the public agenda.

4.4.2 Life cycle approach in the regional policy instrument hierarchy

First of all, we recall the main ways life cycle approach may be useful in supporting policy in different manners (proposed in chapter 4.2):
1. Identification of emerging issues.
2. Definition of policy options.
3. Comparison of options.
4. Lower hierarchical level implementation / Compliance checks.
5. Effectiveness of the policy evaluation of the need to revise (or phase out) the policy.

The following table presents an overview of how life cycle approach can be used and supported in each step of the policy hierarchy. Into brackets we put the reference to the list above.

Type of Policy Instrument	Use of life cycle in the hierarchy
Regional law	Use of life cycle to select/ prioritize policy options – e.g.: assessment of the environmental impacts avoided in the life cycle thanks to the adoption of various actions, with the aim of defining priority scales of the various options on the basis of the best cost / benefit ratio. (1,2,3) A law can also strengthen the requirement of using life cycle approach as a reference decision support system in the implementation phase (therefore at a lower level of the hierarchy). A law can also allocate resources for research and studies to support policy design and implementation, run using several methodologies, included life cycle methodologies.
Regional regulation	A regulation is the first step of the law implementation, which usually goes more in depth into some specific branches or topics of the law. If we intend to use life cycle approach for specific branches of the policy implementation, we can detail this in the regulation, defining the branches and the conditions for the use of life cycle approach. (4) Life cycle approach can also be useful to define in detail the policy options, related to the topic addressed, giving further hints for the policy implementation. (1,2,3) Introduction of eligibility requirements for projects implemented by or with the Regional authority, e.g. minimum life cycle performance for public-procured products or services, or for companies willing to become suppliers of the regional authority.
Plan or programme	Use of life cycle for characterizing specific objectives and actions in the plan (e.g. in the field of circular economy, resource efficiency, innovation, etc.) as well as for monitoring of plans through life cycle based indicators or methods. (1, 2, 3, 4, 5). A Plan or a programme can also allocate resources available for using life cycle approach and ask for capability in life cycle approach for the programme implementation. e.g. the Regional operational programme allocates resources for Technical assistance (TA). Among the requirements of a technical assistance and among the topics the TA have to deal with during its activity, life cycle approach can be foreseen.
Resolution	In the policy implementation pathway through a resolution we can approve a specific methodology for the use of life cycle approach for specific issues/ topics. (1, 2, 3, 4, 5). Introduction in tender criteria of bonuses allowing a significant reduction of environmental impacts or of costs in the life cycle.
Decree	Introduction of life cycle based criteria that must be satisfied by interventions encouraged in projects (access requirements or reward criteria). Rules, conditions and recommendations in permitting decrees, including monitoring aspects.

4.4.3 Examples

Case 1
Water policy
A law can define the regional framework for water protection and use.

A regulation can detail how to manage water concessions.

A plan/programme can check the status of and set the objectives for the regional ground water and surface water use and protection.

A resolution defines methodologies to support sustainable water management (e.g. a policy maker can make a resolution to define how to use life cycle for specific objectives: one of them can be the reduction of water consumption in galvanic industry).

A decree can open a call for tender to select and support projects coherent with what defined from the upstream hierarchy (life cycle is welcome here for instance as a criteria) or to permit projects under specific conditions.

Case 2
Objective
Promoting the use of LCA in projects funded by one of the Axis of the ERDF-ROP, stimulating the organisations taking part in call for projects to use LCA as knowledge base to justify their sustainability proposals, namely to develop more resource efficient production schemes.

Action on policy instruments
Of course, we have to foresee and describe the use of LCA in the **decree** setting up the call for tender through which we are going to support the companies.

But our action can be much more effective if we can foresee the use of life cycle tools directly into the ERDF-ROP (a **programme**) text or into some of its managing tools. Therefore, to be more effective, different actions on different PIs of the hierarchy can be useful.

Case 3
Objective
Using of life cycle based tools to support the waste management policies.

Action on policy instruments
We can use a law to formally recognise the possibility to use decision support tools for waste management and circular economy, among which we can explicitly include life cycle based tools. The law can also foresee the availability of a budget, in order to allow the regional government to use this kind of tools. Then a Resolution can suggest different ways to use life cycle approach. Then, the tools can be applied: to study sectors and solutions in the drawing up or in the enforcement of the waste management programme, using the budget available; to design specific sections or actions of the ERDF-ROP taking into account the results of the life cycle studies. Without this support given in different policy instruments, the application of life cycle could be weaker.

5 Life cycle approaches in local policymaking processes: key sectors, good practices and regional policy analysis

So far, this roadmap has proposed an overview of the life cycle world and an analysis of the policies and of the policymaking to clarify key-concept to be taken into consideration to effectively use life cycle in policies.

It is now time to suggest some concrete hints about some crucial themes concerning the use of life cycle in the policies. These crucial themes were identified by the project as pillars of the LCA4Regions project policymaking and the related concrete examples we propose are the core of the project results, which we think can be of great usefulness for supporting policy makers in understanding where and how to use life cycle approach.

5.1 Key sectors

LCA4Regions project identified 5 fundamental pillars to boost the use of life cycle in policies, especially in regional policies.

These pillars, around which the project analysis and learning were carried out, can be considered as pivotal thematic aspects the policy makers must take into consideration to develop effective policies involving life cycle, in particular in the current European scenario, where some priorities emerge as crucial aspects of the policymaking:

- Resource efficiency;
- Waste management and material flows;
- Green public procurement;
- Training and capacity building;
- Monitoring and evaluating policies.

The importance given in the project to these aspects derives from the crucial role they play in the regional policies and in setting up an effective and supportive use of life cycle approach.

Actually, life cycle approach can guarantee a strong support to a policymaking which intends to be more circular, resource efficient and climate neutral; meanwhile, in order to allow life cycle approach to maximise its benefits to the environment, it is important to use it in GPP policies and to increase the capabilities to use these tools among policy officers, practitioners and businesses. Finally, life cycle can allow a more aware, clear and unbiased policymaking, when it is use for monitoring and evaluate policies.

5.2 Good practices

In order to increase the clearness of our work, we would like to suggest our reader to get closer to some concrete uses of life cycle approach, useful to show, better than long theoretical explanations, the tools introduced before. The project has identified a lot of good practices in all the project pillars. Therefore, we suggest checking the Good Practices Guide, available here, https://projects2014-2020. interregeurope.eu/lca4regions/reports/ to get more information and a clearer overview of concrete applications.

In the following page, a good practice list is presented with its link to the webpage for further information.

Resource efficiency

Substitution of Hazardous substances in Process industry using results of Life Cycle Assessment

Environmental Impact Assessment of Renovated Multi-apartment Building using LCA

Resource efficient land use to promote sustainable land design and development

LCA for evaluation of construction works

Awards: Mais Alqueva, Mais Valor (More Alqueva, More Value)

An ongoing measure of energy retrofit and sustainable renovation of public housing building stock

Energy and resource efficiency in hotel industry

LCA in reducing CO_2 emissions in the production of building components

Environmental Product Declaration as an example of LCA application in construction

Calculation of Carbon Footprint in services of the Commonwealth of the Region of Pamplona

New DISTRICT HEATING with BIOMASS in the framework of the EFIDISTRICT project

Waste and material flows

Application of Life Cycle Assessment in optimization of municipal waste management systems

Lithuanian´s deposit system

Processing alternatives of biodegradable waste- anaerobic digestion, energy & biofuel

Life cycle environmental impacts of construction wood waste and packaging waste processing methods

Promoting the valorisation of material from pruning vineyards.

Optimization of the regional management of Construction & Demolition Waste through the LCT approach

Admixtures for bituminous conglomerates

Cantiere Green Protocol

GERLA project: Waste management in Lombardy – Life cycle assessment

URSA - Alqueva byproducts circulation units

Life cycle assessment of different types of graveyard candles

Comparative life cycle assessment of alternative packaging materials for beverage

Redistribution of charges for environmental pollution into pro-environmental investments

The carbon footprint of the activities of the Food Bank of Navarra (BAN)

AgroPaper, a sustainable and biodegradable solution for the agricultural mulching technique

Public procurement

Management of sustainable procurements at municipal level

Execution of energy planning for building procurement

Public Procurement for Innovation

Purchase of operational leasing and other associated services for electric and hybrid cars

Call for tender "Environmental footprint" and "Environmental footprints project 2018".

The Expo we learned – the legacy of a mega event in a circular economy perspective

Green public procurement and LCC in practice – Green vehicles

Green public procurement in Slovenia

Active support of the contracting authority by the Public Procurement Office through LCC calculators

Manuals of the Public Procurement Office for the dissemination of green procurement and the life cycle.

Environmental clauses in the contract for Pamplona street cleaning services

Healthy and sustainable menus in municipal schools of Pamplona

Training and capacity-building

Study module: Life Cycle Assessment

KEINO Academy for sustainable procurement management

E-learning course on construction and demolition waste: prevention and recovery

Viticulture Impact Assesment on the Environment (VIVA)

UNI CEI 11339 – Italian Certification Scheme for Experts in Energy Management

Training and capacity building on circular economy and LCA in Slovenia

Training and capacity building on LCA in Slovenia

Capacity building in life cycle assessment - Lodz University of Technology

Life Cycle Analysis (LCA) and Carbon Footprint (CF) training courses.

Course "Business Models in the Circular Economy"

Master's Degree in Circular Economy (CE)- Campus Iberus.

| Monitoring and evaluating |
|---|
| Lithuanian Building Sustainability Assessment System |
| Doing good: carbon handprints as assessing positive impacts of companies and the public sector |
| Wines of Alentejo Sustainability programme - WASP |
| LCA monitoring and evaluation in carbon footprint calculations using computer software |
| National Registry of Carbon Footprint (CF), CO_2 compensation, and CO_2 absorption projects |
| Regional Green House Gas (GHG) emissions Inventory |
| Carbon footprint (CF) calculation of the Departments activity in Government of Navarra |
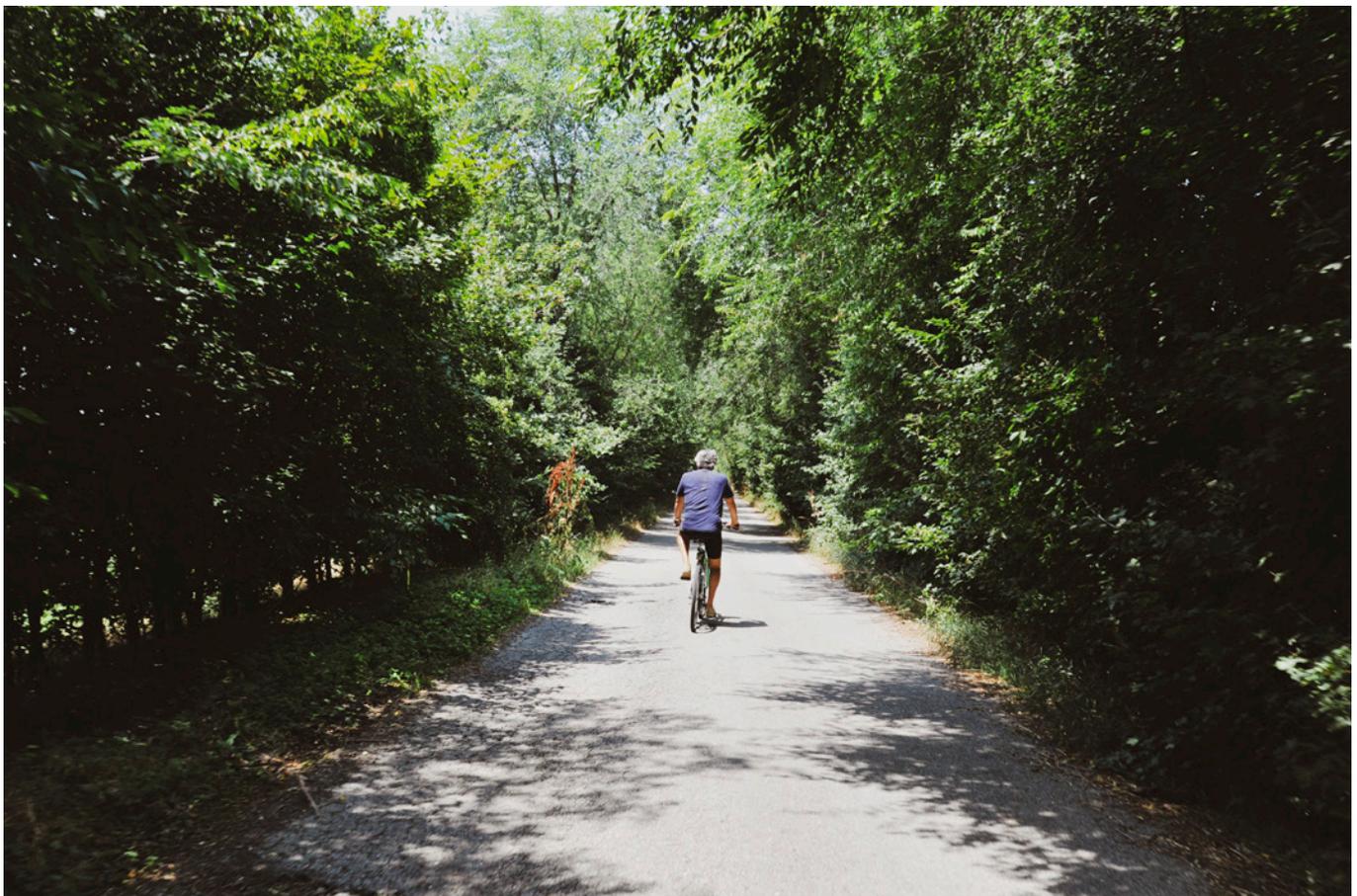
5.3 Regional policy analysis

Finally, the LCA4Regions project's activities delivered specific outputs devoted to analysing each partner's policy contexts and the potential use of the life cycle approach into them. This exercise carried out by the consortium can be inspiring as a concrete example. Detailed information on the policy instruments can be found in the project website at this link, "https://projects2014-2020.interregeurope.eu/lca4regions/library/#folder=3118"

6 Designing sustainable policies

In chapter 2 we proposed an overview of policies and policymaking. In chapter 3 we proposed an overview of the life cycle approach and its tools. In chapter 4 we understood how EU suggests using life cycle for policies and what to take into consideration to use it at local level. In chapter 5 we saw some of the project results and recalled concrete examples and pillars where to use the life cycle approach.

It is now time to propose some crucial steps to bear in mind to design sustainable policies and, therefore, to set the right way to use the life approach for supporting them, given the framework provided in the previous chapters.

6.1 Key steps to design sustainable policies

The waypoints to be considered in designing sustainable policies are the following:
- Identifying:
  - sustainability objectives
  - deleterious circumstances to be avoided
  - and existing problems to be solved
- Set the scope of policy consideration:
  - only local factors considered?
  - or also other communities along the supply or disposal chains?
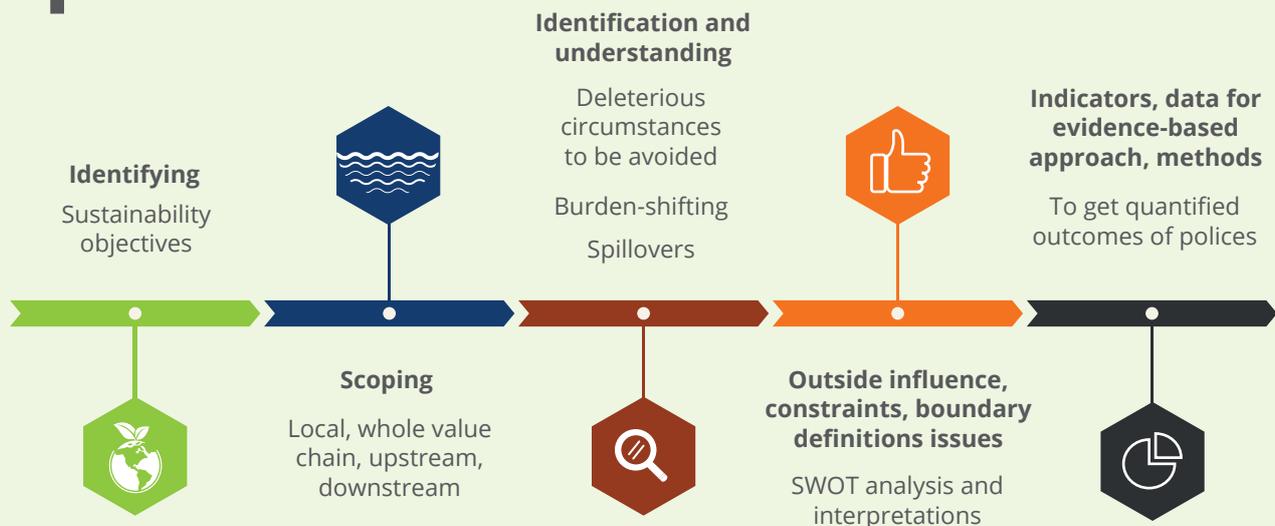 - upstream and downstream factors included?

• Identification and understanding of secondary dependent factors that accompany a policy, and that can be incorporated into the scoping of a life cycle consideration:
  - spillovers
  - burden-shifting
• Choice of sustainability indicators (multidimensional) to be considered and addressed in policy design - i.e. not only climate, not only water, not only health etc. This is important both in sustainability policies (too many of these are one-dimensional) and in development policies (also often very one-dimensional).
• An estimation of the data available for evidence-based thinking and calculation
• Calculation methods and models to use if the policies are intended to have a quantified outcome eg. reduction factors, efficiencies, volume or mass changes etc.
• A SWOT and an interpretation of how the policy dynamics are affected by various outside influences and constraints, data shortage, boundary definitions etc.

The life cycle approach can support several of these steps.

The life cycle thinking is especially important in framing development policies because these often create the greatest sustainability impacts (both good and bad).

Designing **sustainable policies**

Identifying
Sustainability objectives

Identification and understanding
Deleterious circumstances to be avoided
Burden-shifting
Spillovers

Indicators, data for evidence-based approach, methods
To get quantified outcomes of polices

Scoping
Local, whole value chain, upstream, downstream

Outside influence, constraints, boundary definitions issues
SWOT analysis and interpretations

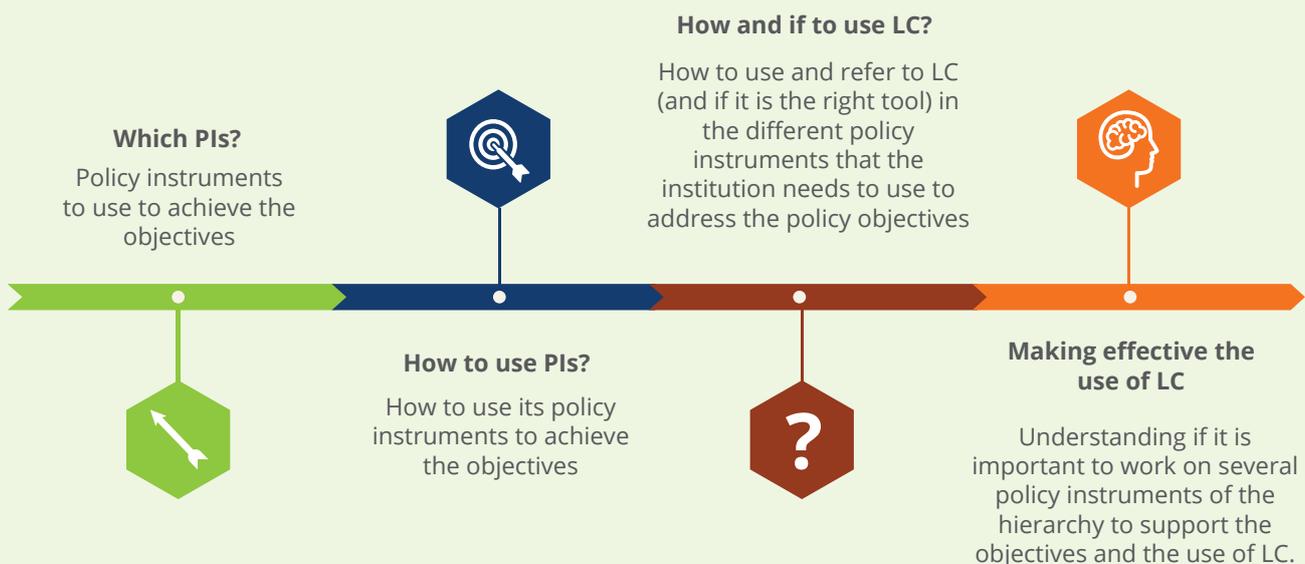## 6.2 Addressing the policies through the policy instruments

Using the life cycle approach any institution wants to address specific sustainability objectives and to carry out the related actions.

Once clearly identified the objectives and bearing in mind the methodological scheme presented in the previous paragraph, an institution has to address the following issues, to set effective actions and policies:
- understanding which are the policy instruments to use to achieve the objectives;
- understanding how to use its policy instruments to support the objectives;
- understanding how to use and refer to life cycle (and if it is the right tool) in the different policy instruments that the institution needs to use to address the policy objectives;
- understanding if it is important to work on several policy instruments of the hierarchy to support the objectives and the use of life cycle.

Policy instruments:
a tool to master

How and if to use LC?

How to use and refer to LC (and if it is the right tool) in the different policy instruments that the institution needs to use to address the policy objectives

Which PIs?

Policy instruments to use to achieve the objectives

How to use PIs?

How to use its policy instruments to achieve the objectives

Making effective the use of LC

Understanding if it is important to work on several policy instruments of the hierarchy to support the objectives and the use of LC.

6.3 Barriers/Opportunities analysis

At this stage, it is time to understand which could be the barriers and the opportunities a policy maker has to deal with in applying life cycle to policies. The awareness of the barriers is crucial because they can hamper, jeopardize, or even nullify the efforts done. The awareness of the opportunities is crucial as well in order to allow the policy maker to define and carry our action as effective as possible.

6.3.1 Barriers

Below, we propose a set of the main barriers
  • geographical and temporal separation between production and consumption; impacts can be located elsewhere and in a different period than where/when the policy is created, therefore the regional institution may not have the authority to intervene on their reduction+ of the possibility to account for the benefits achieved under its indicators;
  • lack of cooperation from stakeholders; in the private sector, actors might consider too high the effort and the cost associated with the realization of a life cycle analysis or of the implementation of actions aimed at reducing the environmental impacts of their product or service; in the public sector, the adoption of such techniques might be perceived as useless due to the limited technical background;
  • high cost of LCA compared to (immediate) benefits; linked to the previous barrier, in many sectors the focus is on maintaining the current status in terms of production processes and characteristics, limiting innovation to the key features that might improve the product, the market access or reduce the production cost; in case LCA is not perceived as an opportunity to optimize processes and the related impacts and costs as well as to improve the sustainability performance of the company, this might constitute a significant barrier;
  • complexity of life cycle tools; studying the impacts and costs associated with the life cycle of a system, a process, a product, etc. is significantly more complex than considering only those directly related to its production or use; moreover, especially if conducted in a quantitative way, it requires the use of dedicated software and databases that are not of immediate use and understanding for non-technical experts;
  • high level of organizational changes required to implement LCM; the adoption of improvements related to the life cycle require significant modifications of the interactions that the institution or the company have with the external world, including suppliers, partners, clients, etc. and this reflects on significant organizational changes needed, which might constitute another relevant obstacle;
  • limited technical background of policymakers to interpret and incorporate LCM in policies; typically, life cycle approach is not among the key competences of policymakers and officers of public institutions, thus the potential for application of these techniques for shaping policies and regulating processes falling under their direct thematic and geographical competence is limited;
  • lack of complete and accurate inventory data; life cycle analyses and thinking need to be based on a deep knowledge of the system under analysis, from the whole region to the specific sector or company; to do this, large sets of primary and secondary data are needed, which sometimes might not be available, making difficult the adoption of life cycle based techniques;
  • too high focus of LCA on quantitative rather than on qualitative factors; LCA is perceived by non-technical experts as a tool providing numbers related to environmental impacts and costs that are difficult to understand and to transpose in real actions; this might constitute an important barrier, in case the most important lesson learnt from LCA is not taken, which is to use it as a tool for understanding interactions and relative impacts of the different steps and phases of the life cycle;
  • high time and resources demand; linked to the previously identified barriers, the adoption of life cycle based tools requires a significant time to create the cultural background and to train officers and operators, as well as to carry out a LCA for a specific product or service, etc.

6.3.2 Opportunities

Below, we propose a set of the main opportunities:
  • increased stakeholders focus on environmental and social aspects; these topics are becoming increasingly important for stakeholders of any level and sector, from private citizens willing to switch to a responsible consumption, to companies willing to optimize their processes and to reduce their footprint, to public institutions and the financial sector willing to support the achievement of targets set at international level; this opportunity can be exploited to increase the penetration of life cycle thinking in organizations at any level;
  • possibility to tailor LCM tools on the specific context; life cycle thinking is not only for environmental analyses but also for economic and social assessments; it is not only for industries but also for services companies and for public institutions; in general, it is a flexible tool for the analysis of any kind of process and organization with the desired target and level of detail;
  • possibility to internalize external factors in the analysis, achieving a more immediate effect; looking "out of the box", upstream and downstream, life cycle thinking allows quantifying also effects occurring out

of the boundaries of the organization, thus accounting for benefits or impacts created along the whole value chain;
• opportunity of cooperation with academia and research institutes to gather technical support; most of the experts in life cycle aspects are working in the university and research world; this is an important opportunity to be exploited by public institutions with an inter-institutional cooperation approach that also enables a significant optimization of costs;
• feasibility of integrating LCM with existing management systems; companies and public institutions are already implementing in most cases systems for the management of quality, of environmental/energy aspects, of social aspects including health and safety; the adoption of life cycle based tools is easy to implement in the context of the existing management systems, since to start it is only required to replicate the approach adopted in the organizational boundaries to other processes and stakeholders across the value chain;
• LCT focuses also on qualitative aspects, not only quantitative results as LCA; the adoption of a more general life cycle thinking compared to a detailed quantitative life cycle analysis is easier and open to a wider range of stakeholders compared to technical ones; nevertheless, it allows significant benefits in terms of understanding the interactions among different stakeholders and processes and identifying opportunities for improvement and for the exploitation of synergies;
• need to involve stakeholders actively in the implementation of LCM tools; a cooperative approach is the best option to implement a life cycle based organization, since this requires contributions from all the stakeholders involved in terms of collection of information and data, identification of interactions, of opportunities for improvement, etc.; it is therefore important to support the collaboration between public institutions and private sector and among different sectors in a life cycle perspective;
• opportunity to extrapolate LCA results in a less technical and more understandable format and language; as mentioned, in addition to detailed LCA reports full of numerical results that might be hard to understand to non-technical experts, the results from the analysis in a life cycle perspective can be also interpreted in a qualitative way, thus gathering the most important lessons learnt in terms of interactions among phases and steps of the life cycle and their relative weights;
• availability of success stories and case studies of successful applications of LCA in public policy; as LCA4Regions project demonstrates, life cycle thinking has been adopted many times in policies achieving significant results in environmental, social and economic terms; this should constitute an important incentive to public institutions to promote policy actions in this field.

6.3.3 Overcoming barriers and supporting opportunities

Below, we propose some examples of actions to overcome barriers and to support opportunities:
• training to policymakers, including political representatives, managers, officers and employees of regional institutions on the potential uses of life cycle thinking at the different levels of the policymaking hierarchy;
• first, start from social and economic aspects: life cycle costing and social life cycle analysis are generally easier to understand by non-technical experts than environmental analyses; the implementation of green public procurement approaches is a good starting points for the inclusion of life cycle thinking in concrete regional policy actions;
• then, start supporting industrial companies willing to invest in circular economy and reduce life cycle impacts of their products, thus starting the creation of a technical knowledge on the environmental side of life cycle thinking;
• exploit collaboration with academia and research centers in the region, which own most of the technical knowledge and can cooperate thanks to inter-institutional agreements, optimizing efforts and costs; also cooperate with other regions and with higher and lower level institutions (EU and national governments on one hand, provinces and municipalities on the other) to define common targets and identify potential actions and areas of intervention;
• exploit the existing management systems, plans, programmes in fields where life cycle thinking can be more easily implemented, on topics like procurement, energy/resource efficiency, climate change, sustainability, waste management, circular economy, industrial competitiveness, innovation, etc. to introduce life cycle based criteria in existing policy instruments.
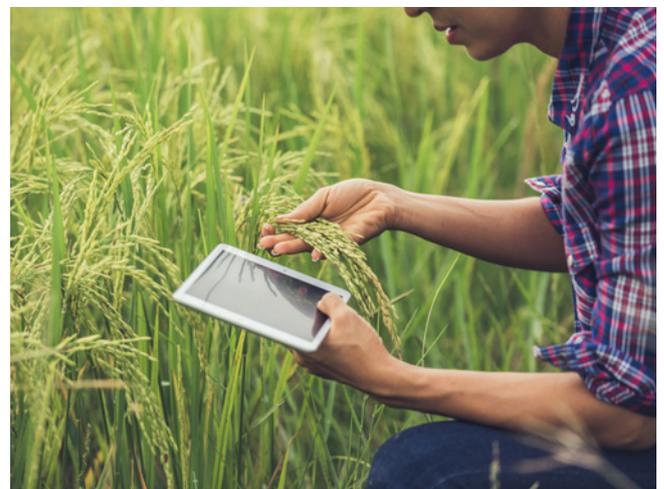
7 Conclusions and inputs for the action plan

The policymaking has to find sound, effective, aware and sustainable paths to address its objectives. Many policies have serious spill-over impacts, burden-shifting and unwanted or unexpected effects. Our world has on one hand, limited resources, increasing population, increased capability of impact on sustainability; on the other hand, it has a widespread awareness and evidence of the need of sustainable policies and of actions capable to produce net positive effects at social, environmental and economic level. Policy action must be as effective and as efficient as possible, minimising deriving problems and costs, at social, environmental and local level.

In this context, the life cycle vision can be a powerful approach to drive us faster towards sustainability.

The EU has already built many of its policies on a life cycle vision.

Development-oriented policies often touch on multiple SDGs simultaneously. This implies that who design and shape those policies must be able to apply a holistic mindset, based on analysis and evaluation tools that can make clear all the consequences of the choices on all the goals involved, allowing aware solutions.

The life cycle approach can help in broadening the interaction with the sustainability agenda, paving the way to more aware, effective and efficient solutions.

Regional action policies, such as circular economy, recycling, waste management, tourism promotion, transport and energy policies, can each have serious upstream and downstream implications that are not always visible and thus often not taken into account, producing further effects, which must be managed afterwards by the policy makers themselves, using further natural, economic and human resources.

Life cycle thinking in the appropriate policies when they are formulated or amended can address some of the above features and avoid or at least minimise the unwanted effects; more over it can also allowed a aware choices, of which the unwanted and negative impacts can be managed, from the beginning of the policy implementation.

We have to keep in mind that LCA methodologies are themselves still evolving further and will change further with time. New methods such as sLCA, O-LCA, LCSA in particular are only slowly gaining traction. Social LCA is gaining more momentum now. LCC is still mostly focussed on the product or policy owner rather that the wider community and external stakeholders.

The life cycle thinking implicates the entire regional administration. It is often mainstream development projects that are the cause of major secondary impacts, and it is necessary to build a life cycle vision in the development-oriented units in administration as much as the environmental department.

LCA in policy has to be led by, and have the support of, the head of administration and the political leadership. Effort has to go into educating this level of leadership about the value of LCA.

EU is providing some leadership through its own policy programme.

The LCA4Regions project has explored most of the above points and has built a solid base from which the partners can move on.

The use of LCA methods in regional policy formulation and implementation can achieve good results, and is cost-effective as it results in fewer spill-over effects that need to be cleaned up.

There is a real need to have closer working relationship and exchange of information between regional officials and the LCA community. Regions need a source of local LCA expertise. In some cases, this needs to be built up through local teaching institutes or taking advantage of the local ecosystem, in terms of existing skills and capabilities.

Finally, this roadmap accompanies the policy maker towards the use of life cycle approach in policymaking, showing how and when the life cycle approach can be useful and proposing crucial themes where life cycle approach can play an important role and key aspects to be taken into consideration for using it effectively.

The roadmap emphasises also the importance on one hand of a correct design and use of all the policy instruments under the responsibility of a public authority, in order to address as effectively as possible the policy objectives; on the other hand, the importance of designing and setting the use of the life cycle approach into those policy instruments in order to make it and all its tools really capable to support sustainable policies.

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