Deliverable 3.4

Indicators Matrix to measure circular economy progress in the four countries.

Project: Evaluation of the Circular Economy current situation for the development of a roadmap for Brazil, Chile, Mexico, Peru and Uruguay

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1. Introduction

This report presents the results of the **deliverable 3.4** Matrix of Project indicators: *Evaluation of the Circular Economy current situation for the development a roadmap for Brazil, Chile, México and Uruguay (RFP/UNIDO/7000003530)*

As it is an evaluation of the current state of the circular economy in Brazil, Chile, Mexico and Uruguay, pioneer countries in starting this process in the region, the first thing is to define a regional approach for the adoption of this development model. In the second instance, a methodological approach is presented through which the National Designated Entities (END) will be able to establish their reference framework and respective system for monitoring progress and impacts during the transition towards the circular economy.

In section two of the document, a study of the state-of-the-art of the different reference frameworks and circular metrics that have been implemented in countries that are considered as benchmarks in the transition to the circular economy, which already present relevant advances, is developed. and lessons from which important learnings emerge for the four countries that are the object of this study.

It should be emphasized that this section starts by showing the results of a taxonomic study of the measurement and monitoring systems of the circular economy (Saidani, M., Yannou, B. 2019), to later address the evolution of the reference frameworks with a national approach, in countries like China, Germany and Japan, respectively. In addition, the comparative analysis is addressed in the evolution of regulatory frameworks and the key elements for the implementation of the circular economy in these nations. Then the framework of reference and monitoring of the circular economy for the Flanders region, Belgium (also known as the Flemish region) is explained, since a regional approach of this nature is relevant for the current context of the four Latin American countries and for a future scenario of regional cooperation that accelerates the adoption of this model of sustainable development.

In the final part of section two, an analysis of indicators of sustainability and circular economy is shown that serve as a reference for the development of the metrics in which each country decides to trace flows of materials, energy and water, as well as socio-environmental impacts. and economical. It is worth highlighting the monitoring framework of the European Union as an open data system where impact metrics are also integrated both at the local level (by country) and at the regional level, which for the four countries could represent an opportunity in terms of transparency, sustainable management in cooperation and measurement of impact before the deployment of projects. At the end of this section, relevant recommendations from the Ellen MacArthur Foundation are presented.

Section three develops the key elements on which the reference framework applicable to the four countries in this study has been developed. It starts from an analysis of the context where determining factors for a sustainable development model are identified both at the country and regional levels.

It should be noted the important role that cities have as centers of economic development and with regard to the challenges of mitigating socio-environmental impacts, infrastructure deployment, as well as trends towards the design of smart cities and the integration of networks of sustainable cities based on the transfer of knowledge, experiences and technology.

In this section, the conceptual reference framework, and an initial proposal of a monitoring system for each country are presented. Additionally, it is essential to understand that this methodological approach may be adapted to the conditions of each context, to the strategic objectives and agendas demarcated by each country, led by the Designated National Entity (DNE).

For the measurement of impacts and progress in terms of sustainability, economic development and circularity, a group of indicators is presented to establish a baseline, which is determined by the data currently available and by the strategic objectives of the country. Likewise, a group of indicators for the transition phase towards the circular economy is proposed as an exit point.

Finally, a dashboard is included to correlate the key aspects for the circular economy of each country with respect to a timeline that starts from the measurement baseline, a transition phase towards the circular economy and a phase frank adoption of this new model of sustainable development. At the same time, these metrics make it possible to visualize progress on each specific issue and measure its level of success with respect to the goals acquired by the country in view of the 2030 Agenda, the Paris Agreement or other national strategies. The measurement scale is relevant since this dashboard is designed to display the indicators at a micro level (companies, specific products and services), at a meso level (productive chains, economic sectors and cities) and integrate them at a macro level (goals and impacts at the national and regional level).

One of the most important challenges for the definition of the reference framework and for the design of the monitoring system (that will measure progress in the implementation of the circular economy roadmap), is the availability of data, for which a national strategy must be developed to ensure the acquisition of data from time to time, to integrate it into key indicators for decision-making and to present it under an open data structure as an exercise of transparency, citizen participation and stakeholder management.

2. State-of-the-art review of circular metrics at macro level

At a global level, the transition toward a Circular Economy has brought challenges in structuring the indicators that allow us to measure the progress in the circularity matter, not only at the business level but to cities and countries (Ellen MacArthur Foundation, 2015a; WBCSD, 2020).

One of the biggest challenges, is that a global agreement about what Circular Economy is does not exist, also there are not indicators defined to evaluate the progress degree of this topic at a nation level.

Some research made by the Program of the United Nations for the Environment (UNEP) evidenced several different frameworks for indicators used to measure the circular economy and sustainable development. These studies revealed that those frameworks are mainly based on materials and solid waste and suggested that the indicators to monitor the progress in the circular economy should include economic, social, environmental, and governance impacts. These sets of indicators would benefit considering the measurement of wellness, equality, and also material flows (European Union, 2008).

Next, is briefly presented some of the frameworks worldwide.

2.1. Taxonomy of the most relevant measurement and monitoring systems for the circular economy

In recent years, an exhaustive review of diverse definitions of the Circular Economy published by different media and studies has been carried out, both by groups of researchers and academics. In this scenario has been identified lack of alienation about the terminology and its definition (Sacchi, A. et al., 2017).

For our analysis, we refer particularly to this studio since is centered in a Circular Economy state-of-the-art and constitutes a taxonomic study of a sample of 327 academic articles related to monitoring, transition, and implementation towards a Circular Economy in different contexts, sectors, and scales (Saidani, M., Yannou, B. 2019).

In like manner, the job developed by Kirchherr et al. (2017) has been referenced. A review through 114 definitions of the Circular Economy coded in 117 dimensions. We took a single unified and synthesized definition:

> *"A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations."*

Ellen MacArthur Foundation (2013) defines the Circular Economy base on three fundamental elements or principles that can be summarized as follows:

- Design avoiding the generation of waste and pollution.
- Maintain materials and products in continuous use.
- Regenerate natural systems.

Starting from these premises and mentioned studies, for this taxonomic analysis, **55 batteries of circular indicators** were found.

Is important to clear out that even though the investigation period started in the year 2000, the first formal publication about circular indicators dates from the year 2010. Is since this year that the amount of publications and investigations has been growing, this reveals a clear interest in the measurement of the advances and impacts that the Circular Economy generates.

For clarity, figure 1 shows the classification of the systems composed by the circular indicator batteries according to their origin, measurement scale, geographical scope, and year of publication, confirming how this research area is in a current expansion.

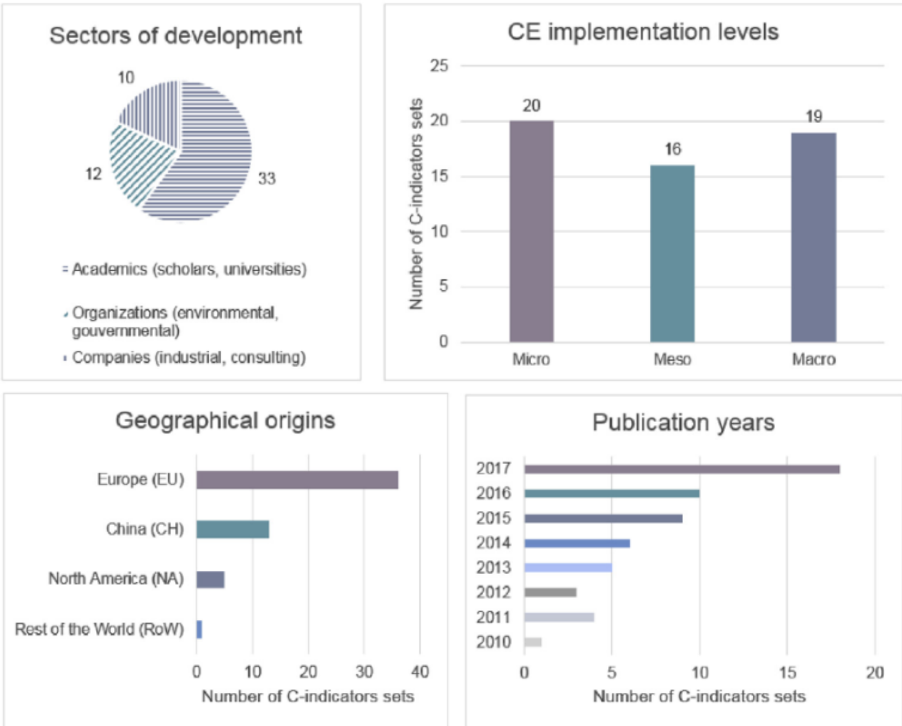


Figure 1: Classification of the measurement systems of the Circular Economy (Saidani, M., Yannou, B., 2019)

We should keep in mind that from the **20 circular micro level indicator systems**, 17 have been developed by European contributors. In the other hand, **9 from the 19 sets of circular macro level indicators** come mainly from cases related to China.

With the aim of classifying, differentiating and guiding the circular indicators batteries use, the following table is presented:

Table 1: Categorization of the circular indicators' batteries defined for the taxonomic study. Adapted from Saidani, M., and Yannou, B., 2019.

CATEGORIES					
	1. LEVELS micro-meso-macro	**2. LOOPS** maintain / re-use / re-manufacture / recycle	**3. PERFORMANCE** Intrinsic / Impacts	**4. PERSPECTIVE** Actual / Potential	**5. USAGES** Improvement / Benchmarking / Communication
	6. TRANVERSALITY Generic / Sector-Specific	**7. DIMENSION** Single / Multiple	**8. UNITS** Quantitative / Qualitative	**9. FORMAT** Formulas / Web-based	**10. SOURCES** Academics / Companies / Agencies

The first category refers to the impact scale of the measurement and monitoring the circular indicators. For this, a classification was determined at the levels **micro** (impacts of the organization, product development and consumer marketing), **meso** (association of businesses for symbiosis in production chains and industrial park) and, **macro** (impact of cities, provinces, regions or countries)

The second category, allows the characterization of the feedback loops, considered by these circular indicators. With it, the degree of industrial performance is monitored from the perspective of maintaining, prolonging the useful life, re-using/re-manufacturing and recycling the material flows, according of the management of the technical resources conceptualized in the butterfly diagram of the Circular Economy, proposed by The Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2015b).

The third category is centered in the circular performance, considering if there exists an **intrinsic** or **consequent** circularity, in other words, the effects generated by such circularity. For example, some circular indicators measure the inherent circularity to the recirculation rates of resources, while others evidence the impacts of the closure of cycles on the sustainability of a productive chain or a territory.

The fourth category adds an essential temporality component in the measurement of the circular economy both in retrospect and in prospective, managing to make a distinction between a **real** (material) and **potential** (goal) circularity.

According with Potting et al. (2016), results quite useful to evaluate the transitions towards a circular economy measuring the progress before (*ex ante*), during (*ex during*) and after (*ex post*) the transition process, as defined below:

> "An ex ante evaluation is relevant to explore whether proposed CE transitions actually have potential to bring about the intended CE effects [...] Ex during evaluation is important to monitor whether a CE transition process follows the planned route and leads to the desired effects. Ex post evaluations should determine whether the effects of the CE transition process are in accordance with the set goals, and whether they actually are the result of the transition activities and the accomplished achievements or were produced by external factors".

In the fifth category, the probable uses for the available circular indicators are highlighted. Such indicators provide data with a certain degree of information about the transition and implementation of the circular economy. This could be used to establish best practices orientated to performance and operative efficiency, or as a support for strategic decision-making, on a better understanding of the context.

In the sixth category, is indicated the degree of the transversality of the circular indicators among the economic sectors, market segments, or industries. Based on the classification of eco-design tools, developed by Rousseaux et al. (2017), it is identified that the generic circular indicators apply to all sectors, to any kind of business regardless of their size, location field, or activity. The specific sectors focus on particular sectorial applications and provide more operational information

The seventh category aims to differentiate between the degree of dimensionality of the circular indicators. Those from low dimension translate the circularity just in a number and are useful for managerial decision-making, while those from high dimension provide a higher level of intelligibility that is more suitable to specialists, experts, designers or engineers in the evaluation of the circular performance of the product or productive process

The eighth category brings information about the units of measurement of the indicators either **quantitatively** or **qualitatively.** The units used to calculate circularity are crucial (Linder et al., 2017). To measure the progress of the transition, quantitative, semi-quantitative, and/or qualitative data must be collected to compile them in indicators that provide significant information.

The nineth level examines the format of the evaluation framework associated with the circular indicators to facilitate their calculation. It has been found that these indicators are linked with formulas for their calculation. This category does not result relevant for the present study.

The tenth category traces the development and origin background of the circular indicators, such as sectors where its development comes from:

(i) Academy and research

(ii) Industrial companies or consultancy agencies

(iii) Government organizations or environmental entities.

A limitation to highlight is the indicators, due to their origin, not necessarily count with the same technical and methodological requirements, nor the same rigor in terms of scientific validity (e.g. Peer review and validation processes)

Next, is shown the distribution for the 55 circular indicator batteries part of the present taxonomic study by Sadaini, M. y Yannou, B. (Saidani, M., Yannou, B. 2019):

Table 2: Distribution of the 55 circular indicator batteries in the principal categories proposed by the present taxonomic study. Adapted from Saidani, M., and Yannou, B., 2019.

CATEGORIES	MICRO	MESO	MACRO
Loops	Recycling (18) Reuse/Remanufacture (13) Maintenance (9) All (9)	Recyling (16) Re-use/Re-manufacture (12) Maintenance (7) All (7)	Recyling (18) Re-use/Re-manufacture (10) Maintenance (6) All (5)
Performance	Intrinsic (16) Impact (8) Both (4)	Intrinsic (9) Impact (11) Both (4)	Intrinsic (17) Impact (15) Both (13)
Perspective	Potential (8) Effective (12)	Potential (9) Effective (8)	Potential (2) Effective (17)
Dimension	Single (12) Multiple (8)	Single (5) Multiple (11)	Single (1) Multiple (18)
Transversality	Generic (17) Sector-Specific (3)	Generic (14) Sector-Specific (2)	Generic (18) Sector-Specific (1)
Format	Computational tool (9) Textual format (11)	Computational tool (4) Textual format (12)	Computational tool (0) Textual format (19)

In the aforementioned document, the 55 sets of circular indicators analyzed are listed, to give a reference of other batteries that have been developed from different areas and with different purposes and scales which seek to measure progress in circularity.

2.2. Circular Economy framework for China, Germany and Japan

The circular economy concept is gaining ground as a sustainable development strategy, not only to reduce greenhouse gas emissions, reduce waste and improve efficiency in the management and re-use of resources but also for the development of innovation and transformation of the consumer markets. This concept has been adopted with great advances by countries such as Denmark, The Netherlands, Scotland, Sweden, Japan, China, and Germany, while in other nations like England, Austria, and Finland, are already considering it within their development plans and national strategies. The concept of circular economy has been used mainly by manufacturing, agricultural, textile, iron, and steel industries but its implementation changes from one country to another. The following is a brief overview of the implementation of the Circular Economy in the pioneer countries: China, Germany, and Japan (Olabode, E. 2019).

China

The research about the level of development of the Circular Economy started in the urbanization processes carried out by the Chinese Academy of Engineering (CAE) in 2005. The first list of pilot models includes 56 companies, 13 industrial parks, 7 provinces and, 5 cities. It was published by the National Development and Reform Commission (NDRC). The second list included 178 companies and was published in 2007 (Liu, Q. 2009). By 2009, the Circular Economy Law was signed by Hu Jintao (former-president) and started to operate in 2009.

The Circular Economy was incorporated as a medium-term plan within the 11° Five-year Plan (2006-2010) and ratified within the 12° Five-Year-Plan (2011-2015) of the government, as part of the National Strategy for economic and social development. This was supported by laws, decrees, and policies created particularly to stimulate a system of cleaner production (CP), the prevention from contamination, and better waste management. In a great manner, the policies and regulations were developed and adapted from the regulatory frameworks from Germany and Japan. However, the Circular Economy Law from the Popular Republic of China represents the first national law worldwide that claims an economic model different from the principal current that has been based on a linear economy.

The enabling public policies that supported this National Circular Economy Law are presented in **Tables 3** and **4**.

Table 3: Enabling public policies that supported the National Circular Economy Law in the Popular Republic of China. Adapted from Olabode, E., 2019.

Area	Policy/Law	Year
Cleaner production	Cleaner production promotion law	2002
	Methods of cleaner production audit and review	2004
Pollution and waste management	Law for environmental pollution of solid waste	2004
	Amended law on pollution prevention and control of solid waste	2005
	Laws and regulations for reuse and recycling specific solid waste	ongoing
	Amended law of the prevention and control of environmental pollution by solid waste	2016
	Environmental Protection Tax law	2018
Energy conservation	Law for energy conservation	1997
	Medium- and long-term plan for energy conservation	2005
	Law for renewable energy	2005
Circular economy	Circular economy promotion law	2009

Source: Adapted from Li, Bao, Xiu, Zhang, and Xu [38] and Su et al. [11].

The main objective of this law was focused on improving efficiency in the use of resources and **disengaging economic growth from the use of natural resources** such as water and land. **The scope of this law comes from top to bottom**, which implies a command and control system of the government towards the industry and society.

The implementation of the Circular Economy model was structured in three layers, according to Su et. al. This goes from the micro to the macro level through a meso level that establishes a bridge between both (Su, B. et al., 2013).

Table 4: Implementation structure of the Circular Economy in the Popular Republic of China. Adapted from Olabode, E., 2019.

Areas	Micro (Enterprise)	Meso (Inter Firms)	Macro (Provinces, Region, State and Cities)
Design	Eco-design	Environmentally friendly design	Environmentally friendly design
Production	Cleaner production	Eco-industrial park	Eco-city Eco-municipality Eco-province
Consumption	Green purchase and consumption	Environmentally friendly park	Renting service
Waste management	Product reuse and recycle system	Waste trade market Industrial symbiosis	Urban symbiosis

Source: Adapted from Su et al. [11].

In a micro-level, eco-design is incorporated from the early stages of product development; this guarantees the reduction of energetic consumption during the whole life-cycle of the product. The eco-design principles applicable to this level include the design for re-use and recycling of materials, disassembly design, maintenance and durability design, design for energy efficiency, and design for flexibility. The focus of the Circular Economy in this micro-level is the **Cleaner Production (CP)**. This directly affects the re-use of resources and the recycling rate of by-products to achieve dual objectives of both environmental and economic performance, the reduction in the use of toxic substances, the efficiency in the consumption of materials, energy, and resources, and the reduction of greenhouse gases, pollutants, and waste.

At the meso-level, the development of those eco-designs that ensure the efficiency of the resources, the life-cycle, and the ability to update products to achieve industrial symbiosis processes is promoted. Similarly, the re-use and recycling of products within the industrial parks and productive chains are essential in this implementation agenda. This ensures the effective circulation of resources inside provinces and regions. In this context, they coined the concept of the *eco-industrial park* as "a community of manufacturing and service companies that seek better environmental and economic performance through the collaboration in the management of the environmental problems and the resources".

At a macro-level, the collection processing storage and distribution systems of products at the regional, provincial, or municipal level are key to developing an environmentally friendly production, activating sustainable consumption and energetic efficiency systems. In production areas, cooperative networks between industries, and industrial parks of primary, secondary and, tertiary sectors should be consolidated to facilitate these exchanges of material, energy, and water flows.

> "The principles of the 3R's are achieved through the Re-design and Re-configuration of the city's and industrial infrastructure, by its regional characteristics, as well as the gradual elimination of large polluting companies, while supports high-tech industries " (Olabode, E. 2019).

The categories identified macro-level include:

- Industry development for material recovery, reuse, recycling and safe treatment.
- The development of organic farming, which has had a long history in China.

Some cities and districts, as Shenzhen in the Province of Guangdong, Wuhan Huashan in Hubei, Zhenjiang Guantang in Jiangsu, Kunming Chenggong in Yunan, Sanming in Fujian y Zhuhai Hengqin in Guangdong were proposed to be low carbon cities. The Chinese government defined thresholds for them, including rates for economic growth, energy consumption, sustainable urban construction practices, government support and sustainable residential consumption.

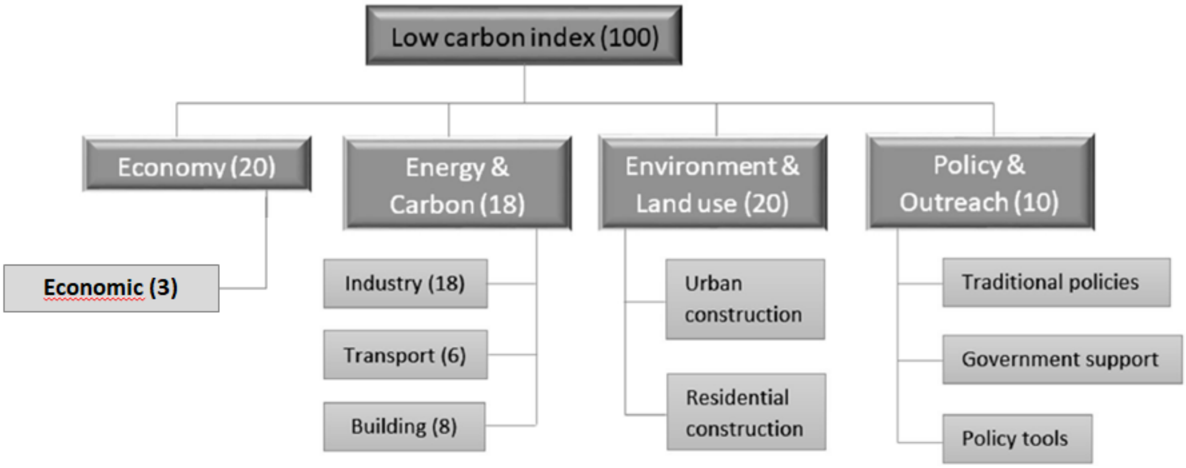


Figure 2: Benchmark index of low-carbon cities in China. Adapted from Saidani, M., and Yannou, B., 2019.

Germany

Germany went through a major energetic crisis and recessions between the 1960s and 1970s, which forced the government to make strategic decisions toward economic diversification. With time, problems associated with a highly extractive economy and poor management of resources and waste generated by industry appeared, for this reason, in 1972 the first Waste Law was published. A year earlier, the Government of the Federal Republic developed a Holistic Action Plan, accompanied by an Environmental Program where the guiding principles were focused on the protection of the environment, prevention of the degradation of natural resources, causal responsibility, and the cooperation, which ultimately led to the development of this new law.

Sensibility to effective waste management, including the developing of collecting methods, classification of material flows and alternatives to re-use, characterized this period from late 1980s. Even though the waste management in Germany was cost-effective, was necessary an evolution of the development model under a Circular Economy focus, that incorporates the principles of sustainable development.

By 1994, this new approach was incorporated into the German constitution through the Regional Planning Law and the Construction Code in 1998 respectively. This process was a natural consequence of the government's commitment to safeguard available natural resources, protect the environment, reduce soil degradation and contamination, conserve biodiversity, and promote sustainable use of resources. This model of sustainable development included special laws for the conservation of natural capital, as well as the regulations that promoted the deployment of energy generation projects with renewable sources and/or energy efficiency. In addition, an Environmental Information Law was developed. This regulatory framework became the platform to catalyze the shift towards circularity.

By 1996 the German Parliament approved the Circular Economy Law called "kreislauwirtschaft". According to Geng, Sarkis, Ulgiati y Zhang (2010), with this law, it sought to reduce the amount of land destined to uncontrolled landfills[1], for which it was designed a strategy based in the hierarchy of waste use that allowed to mitigate the generation of waste and maximize its reuse, recycling, and re-use of closed energetic circuits.

With this new development model, some laws were reformed and implemented, policies and regulations oriented to guarantee the circularity in materials, substances, and energy flows. For example, all the obsolete electric and electronic devices should go back to the industry, this is the reason why all the producers are required to accept them without any charges to the consumer from March 2006, date when the mandate was established. The same way was forbidden to send waste to landfills since 2005 to eradicate the operation of landfills for 2020, improving infrastructure and mechanisms that enable recycling and re-use of waste.

Currently, **about 50% of waste goes to the recycling chain, while 0% of the municipal waste has been deposited in landfills since 2009**.

From the year 2012, the laws of waste and circular economy have been revised and redefined with the implementation of the directives of the European Union, including the improvement of the protection of the environment, climate, and resources.

Table 5: Enabling Public Policies and Regulatory Framework evolution toward Circular Economy in Germany. Adapted from Olabode, E., 2019.

Laws, Polices and Acts	Year
Waste Disposal Act	1972
Federal Emission Control Act	1974
Producer Responsibility for Packaging waste	1991
Closed Substance Cycle and Waste Management Act ("kreislaufwirtschaft")	**1996**
Battery Ordinance	1997
Ordinance on Bio waste	1998
Packaging Ordinance	1998
Renewable Energy Law (Erneuerbare-Energien-Gesetz EEG)	2000
Ordinance on environmentally compatible storage of waste from human settlements	2002
End-of-Life Vehicles Act	2002
Ordinance on the Management of Waste Wood	2002
Landfill Ordinance	2002
Ordinance on the management of municipal waste of commercial origin and certain construction and demolition waste	2002
Stowage Ordinance	2002
The Waste Storage Ordinance	2005
Electrical and Electronic Equipment Act	2006
Circular Economy Act ("kreislaufwirtschaftgesetz KrWG")	**2012**
Amended renewable energies act	2017

Japan

Japan is an island with a high population and an important extension of mountainous land, that initiated its path toward a circular economy model after the global financial

[1] Uncontrolled landfills (definition used by the Inter-American Development Bank) are also colloquially known in Mexico as "open dumps".

crises that affected its economy since the post-war period. The transition to circularity was mainly triggered by the lack of space for the location of landfills due to the rocky topography and the limited availability of internal resources for industrial products such as metals and minerals. This transition started by 1970, even if the notorious results were evident in the face of the implementation of the Law for effective use of recyclables cast in 1991. This is the reason; Japan has become the first country to promote laws about the circular economy.

The strategies used were orientated to the reduction of the dependency on the oil and the high energy consumption industries, such as the reconfiguration of the energetic matrix, and the development of the knowledge economy.

By 2007, 98% of metals were circulating in the recycling chain, while only 5% of the total waste was put in landfills. The **forced consumer responsibility** makes the final user take back any electronic device to the production chain resulted in recovery between 74 and 89% of the materials part of a product. The transition toward a circular economy in Japan has been characterized by a model of **effective collaboration between consumers and producers.**

This market transformation and production chains were driven by the development of high technology, achieving a decoupling of the use of non-renewable resources necessary in production, and creating mechanisms for the deployment of energetic generation projects with alternative, and renewable sources. This has provided a solid foundation for the Japanese economic system, which has allowed the reconstruction of the society on a development model based on the principles of the Circular Economy integrating its people, through the optimal use of non-renewable resources or redirecting the consumption towards the use of renewable ones, according to Ji, X. et al (2012).

The implementation of the concept of circularity in Japan followed a top-down approach, supported by legislation and a strategic regulatory framework. To do this, the government developed a comprehensive that would facilitate the transition and strengthening of society in the circular economy, which later became a pattern of consumption and national lifestyle. The most relevant steps defined by the Japanese government that has guaranteed the circularity in all sectors include:

The creation of educational content on environmental awareness, which is taught in schools, universities, companies and communities.

- The creation of educational content on environmental awareness, which is taught in schools, universities, companies, and communities.
- The provision of laboratories for recycling in schools.
- The deployment of circular commercial markets for companies to deliver, market, or exchange their discarded resources.
- The design of incentive programs to improve public collaboration.
- The deployment of infrastructure that enables the recycling of the discarded resources to be linked.

Benton, D. y J. Hazell (2016) as analyzed the role of the public sector to include the separation of sources of recyclable materials, for the immediate payment of recycling fees and the protection of the rights of the consumers, as well as the roles of manufacturers with the use of more recovered and recycled materials, with the production of durable products and design for repair, reuse, disassembly, and recycling.

The Circular Economy in Japan was developed in such a way that today the flows of materials or products that are no longer in use are easily collected; the cost of return and recovery has been added to the price of the product on the market and all companies are required to recycle their products. Also, recycling systems aimed at generating zero-emissions were developed, minimizing the amount of waste, maximizing the recycling of discarded resources, and in connection with the industrial chain of recycling, transportation, and commercialization of these flows. The systems described have been backed by laws, policies, decrees, and their respective regulations. Below is a list of the eight most relevant laws in this context.

Table 6: Enabling public policies that supported the Regulatory Framework in Circular Economy for Japan. Adapted from Olabode, E.; 2019.

Fundamental and Enabling Laws	Year
Waste disposal law	1970
Resource efficient law	1991
Environmental law	1993
The law of separate collection and recycling of container and packaging	1995
Special household machine cycle law	1998
Sound material cycle society law	2000
Building construct recycling law	2000
Polychlorinated biphenyl waste properly handle special measures law	2001
Vehicle recycling law	2002
Recycling based society law	2002
Revision of the waste management act	2010
Small home appliance recycling act	2013

Source: Adapted from Geng et al. [37]; Ghisellini et al. [39] and Ji et al. [27].

Comparison between the development of CE in China, Germany, and Japan

The following figures summarize the development models that the Circular Economy has been implementing in China, Germany, and Japan, respectively. We must bear in mind that the transition and implementation occur from the design, production, and consumption stages and not only in the final stage of waste management. In this context, a comparative analysis of how the economic model of these countries has been transformed follows:

- In China, eco-design is introduced from the earliest stages of product design to ensure the development of environmentally friendly products and thereby protect natural capital, while in Germany and Japan, manufacturers are responsible for adopting high-tech design practices to facilitate the repair, disassembly, reuse, and recycling of products and components. This finding implies that manufacturers/producers adopt a model of thinking based on the life cycle of the product that is introduced from the design phase to ensure that its environmental impacts are duly taken into account.

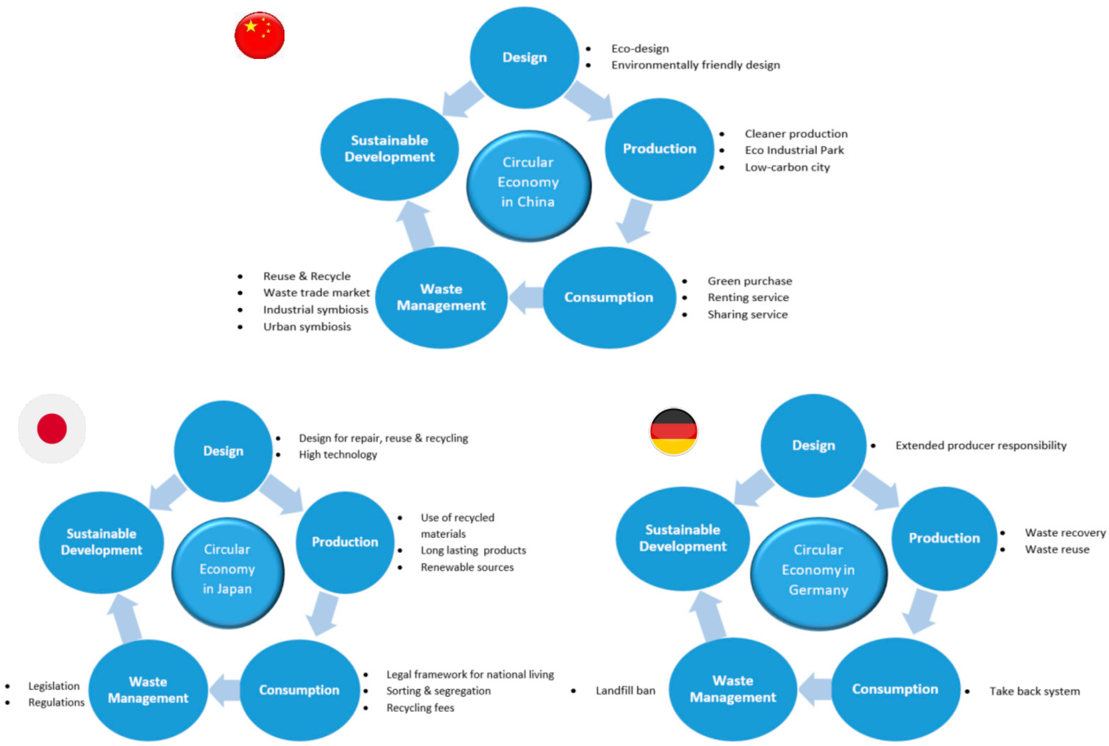


Figure 3: Development of Circular Economy in China, Germany and Japan. Adapted from Olabode, E., 2019.

- As observed, a cleaner production model is implemented in China, the concept of eco-industrial parks and low-carbon cities, which anticipates an approach that goes from micro to macro. Similarly, steps are being taken in Germany and Japan to recover and reuse discarded resources, use recycled materials, use renewable energy sources, and manufacture durable products. This reduces the pressure on the extraction of virgin raw materials during production and greatly reduces GHG emissions.
- Consumers play a vital role in ensuring that materials circulate continuously at the end of their first useful life, thus minimizing the impact on ecosystems. To this end, Chinese consumers are encouraged to live a **low-carbon lifestyle** through green product purchasing, trading, and rental services. Similarly, Japan has a **national framework for life** that provides waste management guidance for businesses and consumers, including sorting, segregation, and recycling. Conversely, manufacturers, and retailers in Germany are required to implement a return scheme, a system that allows consumers to return used or damaged products at no cost. The finding of this study implies a win-win-win situation in the consumption stage for both consumers, manufacturers, and the environment.

  Regarding waste management measures, China has adopted the markets for reusing, recycling, discarded resource trade, and has explored processes of industrial and urban symbiosis, which has allowed it to keep discarded materials, parts, and products for a longer time in circulation. All of this is duly has been supported by **legislation, policies, and regulations**. Similarly, the

prohibition and legislation about landfills are waste management measures in Germany and Japan, respectively. It is evident that the **Law of Efficient Use of Resources of Japan** and the **Law of Waste Management** added to the **Closed Cycle of Substances Act of Germany** were postulates that have contributed to achieving the same purpose. The existence of an appropriate regulatory framework is essential for the success of the Circular Economy and in achieving the goals and objectives of sustainable development. **The implication for countries planning to adopt this concept is to first formulate enabling public policies, such as landfill prohibition, extended producer responsibility, and the mentioned return schemes.**

Table 7: Comparison of the EC implementation process and waste management laws in China, Germany, and Japan. Adapted from Olabode, E., 2019.

	China	Germany	Japan
laws/policies	Cleaner production/Circular Economy law	Closed substance cycle and waste management act	Resource efficient law
Year	2002/2009	1991	1996
What prompted it?	Environmental issues resulting from rapid industrialisation and infrastructure development	Environmental issues resulting from economic diversification	Global financial crises and lack of landfill space due to rocky topography
Why (purpose)?	To stimulate cleaner production, prevent pollution, and control waste	To reduce land for waste disposal, shift responsibility to producers, and ensure waste recovery and reuse	To reduce oil dependence and high energy consumption. To adjust energy structure To improve efficiency of energy utilisation
	The need to reduce reliance on imported raw materials and pressure on domestic resources		
How (approach)?	Top-down	Top-down	Top-down
Implementation method	Vertical approach Micro (Enterprise) Meso (Inter-firms) Macro (Province) Horizontal approach Link between industries, infrastructure, environment, and social consumption systems	Individual Enterprise Administration National	Enterprises Industrial Parks Society

It is clear that the common approach to implementing the CE is the top-down approach. It aims at achieving specific goals or objectives through policies. This implies that policies are imperative to implement the CE successfully. In addition, the method of implementation across the three pioneer countries is similar, cutting across individuals, businesses, industries, governments, and the environment. This suggests the need for all stakeholders to support and commit to the CE or waste management policies as shown in Table 5. The implication for countries proposing to adopt the CE concept is to carefully analyse their waste problem and to determine the appropriate country-based implementation approach and method.

Conclusion of the comparative analysis between China, Germany, and Japan

According to the mentioned study, the concept of the Circular Economy in China was focused on three layers: micro, meso, and macro. In Germany and Japan, it has been implemented through specific legislation, public policies, and regulations.

The Circular Economy law was focused on resource efficiency and cleaner production in China, while in Germany and Japan, it was based on waste reduction and landfill prohibition laws.

The Chinese Circular Economy Law is similar to the Closed Cycle Substances Act and the Waste Management Law in Germany. Similarly, the Act of Efficient Use of Resources from Japan. These laws, as emphasized in the study, were enacted to reduce the extent of land intended for waste management and final disposal (landfills), to transfer responsibilities to manufacturers, and to ensure the recovery and reuse of discarded resources, improving energy and productive efficiency.

On the other hand, the concept of the Circular Economy is developed in four main stages: Eco-design, production, consumption, and waste management. The approaches adopted by the countries analyzed in these stages are similar and aim at achieving sustainable development. The common implementation approach for the Circular Economy goes from top to bottom in all three countries. Enabling policies and regulations, as well as the collaboration and support of all stakeholders, especially consumers, are essential for a successful implementation. This process requires adequate planning to identify the appropriate implementation method and **according to the socio-cultural condition of each country.**

2.3. Circular Economy monitoring framework for Flanders Region, Belgium

Flanders[2] is a region in northern Belgium that borders on the west with France. On the south with Luxembourg and the east with Germany and the Netherlands. It concentrates on 6.5 of the 11 million inhabitants of the country so that around 60% of the commercial and industrial activity of Belgium takes place in this region.

This section shows the most relevant aspects of the reference framework for the measurement and monitoring of the transition and implementation of the Circular Economy[3] designed for this region since it has a structure that connects elements similar to those found in the four countries of which this study is the object.

The first aspect to keep in mind is that this frame of reference consists of three levels:

• **MACRO:** Composed of indicators focused on material flows, which allows monitoring of the environmental, economic, and social impacts associated with the Flemish region, including those effects outside the borders of this region.

• **MESO:** Level composed of indicators focused on achieving the Circular Economy in particular systems, facilitating the measurement and monitoring of the performance of production chains and economic sectors as a whole.

• **MICRO:** Composed of a set of specific products and services, aimed at establishing a representative and broad sample of our daily consumption and which is also relevant taking into account the transition to the Circular Economy.

Below is a graphic summary of the conceptual structure of this frame of reference:

[2] Flanders is also known as "the Flemish region" and is located in the north of Belgium.
[3] The methodology presented in this report will be the guide for the country to define its reference framework, monitoring system and roadmap towards the circular economy, based on key aspects and sectors for the country's context.

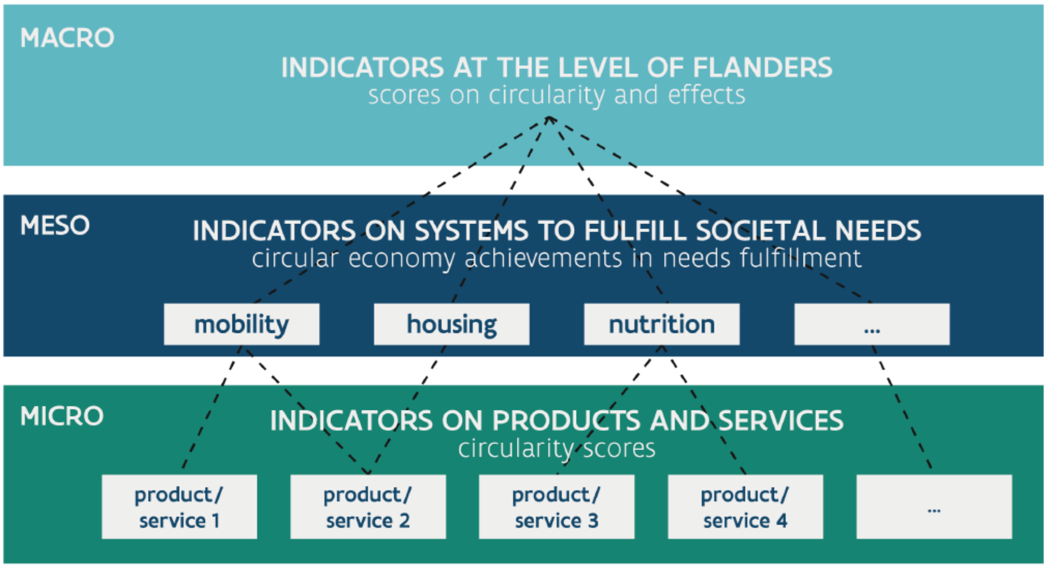


Figure 4: Scheme of monitoring the circular economy in Flanders, Source: adapted from Alaerts, L. et al., 2020

Within the context of measuring and monitoring progress and results on the transition to the Circular Economy, we have reference frameworks and systems that, although they fulfill this function, are relatively new and are still under development. That is the reason why some advantages are identified under this perspective, and they are described below:

- Since the satisfaction of the needs of the consumer market is facilitated by the offer of products and services, a bridge must be established between the micro and macro monitoring levels, this is the reason why the meso level is included. This allows tracing the specific effects of innovation on a product or service and, at the same time, lays the foundation for the construction of public policies for the long term.
- The models of production and consumption play a determining role in the useful life of the products or services that are available to satisfy the needs of the market. From a monitoring point of view, a clear position is redefined for circular business models, an aspect that until now has received little or no attention within the conceptual frameworks of impact monitoring.
- Another aspect that has received little attention in this context is the perspective of the final consumer. With this inclusion, it is hoped to adequately characterize the intersectoral nature of the transition of the Circular Economy and reorient the relationship between it and the manufacturer.
- The feedback obtained through this continuous monitoring from the micro-level is direct, compared to those macro-level indicator measurements that only make visible the evolution of the Circular Economy by registering considerable impacts that are also updated infrequently and usually late.

In short, one of the fundamental principles of the Circular Economy is to keep products and materials in use with the highest appreciation and for the longest possible period, while reducing their socio-environmental impacts. The result of this will be visible through the monitoring indicators and will be comparable with the existing developments (based on the Business-As-Usual production concept, most of them), through which the social needs themselves are currently satisfied, what we will call **Baseline**.

In this sense, the role of the Circular Economy should focus on maintaining the development model within **a safe zone concerning the planetary and social limits** on which this frame of reference is based. This contrasts with the current model based on a linear economy, where products and materials are highly consumed at a high rate and end up as waste after a short time of use or consumption. This accelerated rhythm has brought us into the **danger and vulnerability zone** in several of the dimensions established by planetary limits, including the **loss of biodiversity, climate change, and the global imbalance of natural cycles**. Additionally, we know that social benefits are not equitably distributed, which shows that this current linear model has a double deficiency.

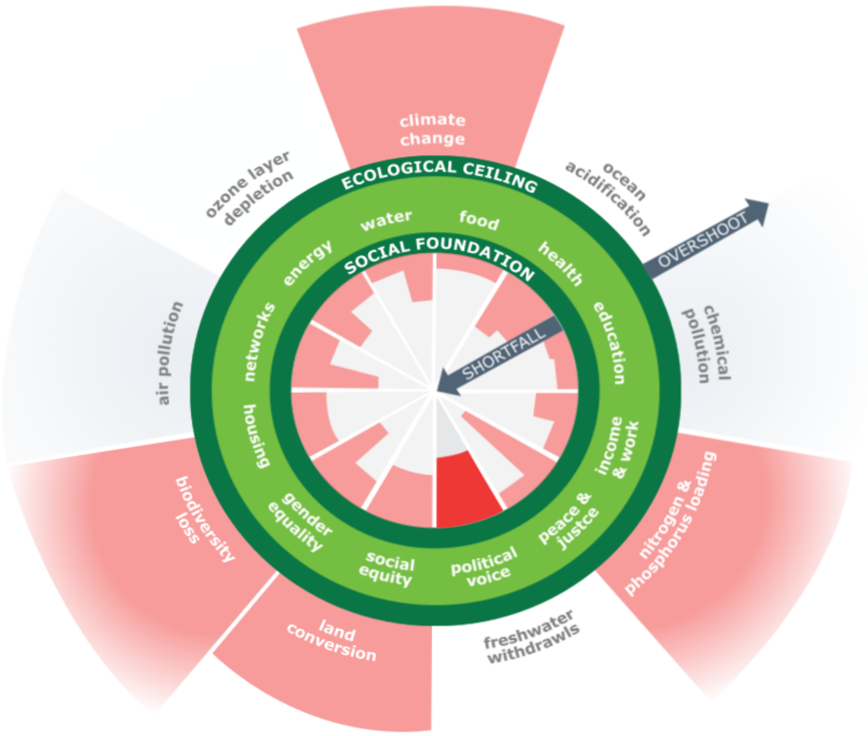


Figure 5: In light green the Safe Zone of economic development is observed with respect to the planetary limits (ecological ceiling) and the social limits (social foundation). Source: Kate Raworth, 2018.

Measuring the Circular Economy

On the road to the Circular Economy, our society needs to experience a systemic change. For this purpose, the Flemish political system is considered to be the main target audience within this frame of reference, since this will eventually be an instrument fed with the data that will determine if the Flemish region is on the right path drawn towards the Circular Economy and how far is from the fulfillment of the goals determined in the roadmap. This framework should also provide inputs and evidence that can be used for the continuous transformation of public policies through legislative interventions addressed to sustainable production and consumption patterns. Based on the presentation of consistent and reliable data, feedback, and comments to the regulatory framework will be enabled and exposed, also giving visibility to the co-responsible areas.

Additionally, this monitoring system should provide information so that the various key actors **identify the potential of the role they could assume** and those needs that they might have in the face of this transition. In parallel, at a broad social level, this frame of reference will allow politicians and legislators to assess the degree of environmental, economic, and social impact that the Circular Economy is having on different sectors and levels.

There are fundamental aspects used to define the indicators that will make it possible to monitor the transition, and they are described below:

- Build indicators to monitor each phase of the transition. It is required to define the input data and the activities catalyzing this transformation of the development model and show the progress. Also, the evidence that the materials and products are maintained at the highest possible levels of recovery or use. All this has a direct result in economic, social, and environmental terms.
- Also, a meso level is required to determine the results concerning the subregions, economic sub-sectors, industries, and productive chains, and even industrial parks with potential for symbiosis.
- At the micro-level, the transition to circularity must permeate companies and the development of products and services. It is at this level that notorious, short-term results will be obtained in a more direct way, which will also facilitate the measurement of the impact of the regulatory framework and the enabling mechanisms of the Circular Economy.
- This transition is directly attached to **technological development**. Mainly because of the complexity in the composition of a high percentage of the materials, components, and products that circulate today, and that should go towards revaluation and reuse chains (recovery, manufacturing, recycling, cycle closure, etc.). In this sense, the measurement of supply and material flows at the macro level, and of the properties of the products at the micro-level, also should be considered. However, the transition to the Circular Economy must address **socio-institutional changes**, in which technology is not the protagonist, but acts as an enabler of the model. An example of this is the emergence of the **shared economy**, which depends on mobile networks that facilitate and support shared service models. Although the technology was not developed for this purpose, it plays a fundamental role.

In terms of monitoring, the Flemish region could be compared to the dynamics of a country and is considering this condition that the reference framework has been established. The need for indicators has been spread increasingly to more aspects, such as cities, regions, and projects. As an example of this, there are connections with initiatives like the Urban Agenda or the **Horizon2020 Project SCREEN**[4],.

- For the year 2017, the French Government published a monitoring framework consisting of ten indicators focused on three areas: Waste management, the supply of economic actors, and from the consumer. The results are presented on

[4] HORIZON 2020 is a research and innovation program of the European Union with a fund of 80,000 million euros to finance projects focused on ensuring Europe's global competitiveness, with an execution period of 7 years (2014 to 2020).

a board where progress is communicated through color code. Some comparisons at the European level are already available. It should be emphasized that five indicators measure the use of materials and the generation of waste. Except for food waste, the quality of the available data is high.

- By the year 2018, the Dutch Environment Agency (PBL) published a framework for monitoring the Circular Economy that includes an in-depth analysis of the monitoring challenge itself. This report provides a complete description of what should ideally be measured to cover all aspects of the Circular Economy in each of the transition phases. In a subsequent step, the proposed framework should be nurtured with the data available today. This exercise concludes that currently at the macro level, various aspects related to material flows can be measured from a perspective of circularity and its effects. Also, an agreement was signed at the level of five priority sectors in the Dutch economy regarding the Circular Economy, in alignment with the agreements between those sectors and the government, called Grondstoffenakkoord2 (The Raw Materials Agreement).

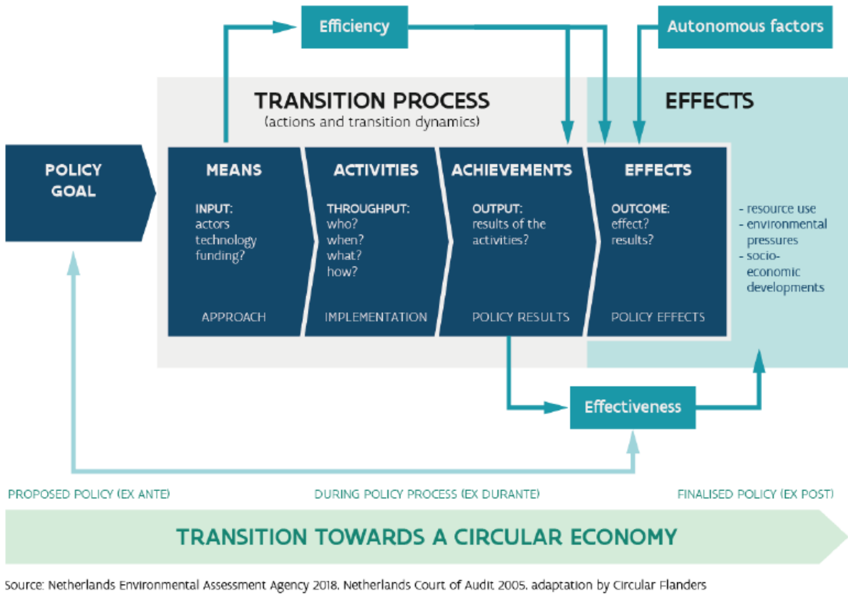


Figure 6: Framework for evaluating progress in the transition to the Circular Economy (Algerts, 2020).

- The same year, the European Commission published a reference framework document based on ten indicators. Those indicators were grouped into five topics: production and consumption, waste management, secondary raw materials, competitiveness, and innovation. Two clear decisions from the start of development were made:
    - Maintain the effects in other domains (such as the environment) and
    - Make the best use of existing data so as not to increase administrative burdens for companies and governments.

Most of the indicators have been taken from other frameworks previously developed at the European level, such as the Waste Framework Directive, the Raw Material Scoreboard, and the Resource Efficiency Scoreboard (Moraga, G., 2018). This framework establishes the baseline from the start, so to the extent that data is available in each country, the indicator scores will be available on the Eurostat platform.

Similitudes and differences between the three Reference Frameworks described:

The general similitude between those three frameworks is the emergence of a series of macro-indicators about materials, discarded and recycled resources, direct material input, the amount of municipal waste per capita, recycling rates, etc. Easily collected data support these indicators because of waste and material management. Also, none of these frameworks is an attempt to summarize monitoring in a single mark.

The differences between the existing frameworks lie in the way in which the aspects of the Circular Economy that are not currently covered by the data are treated, more specifically in the conceptual design of the monitoring systems. In another sense, the Dutch report develops more deeply the monitoring process of the Circular Economy, and it defines the different dimensions that will help to track the transition from input to result and highlights the added value of micro monitoring. Speaking about the monitoring framework of the European Commission, the scope was reduced, and they borrowed the chosen indicators from the existing frameworks.

In conclusion, the unavailability of data is a clear bottleneck for monitoring the transition to the Circular Economy. Furthermore, the conceptual basis and scope of a monitoring system are crucial because they determine the feasibility of managing the information in those areas where the data is not yet available.

It is essential to first establish what is missing, and then try to build a reference framework that can include these aspects in the best possible manner. The following aspects would be valuable in the process of development of a monitoring framework to better reflect progress on the Circular Economy implementation roadmap:

- Establish a link between the micro and macro-level indicators. While there is a lot of literature on the creation of micro indicators, it is currently unclear how they might relate to the macro-level (Vercalsteren et. al., 2018). The added value at the micro-level is that both policy interventions and innovative practices are materializing there first, offering the opportunity for more direct feedback.
- Develop a mechanism to assess the development and potential of circular business models. Monitoring these elements will allow public policymakers to verify and ensure that progress moves away from the current linear economy model of doing business where the transfer of a product is central.
- Establish a link with the possible impacts of the Circular Economy on people, the planet and society, including impacts outside the territory itself. Some examples of the added value of making this link are demonstrated in the Dutch framework at a macro-level, since it allows conclusions to be drawn about the degree to which the consumption of materials moved to other countries (Potting, 2018), thus creating externalities or side effects.
- Give greater prominence to circular economy strategies beyond recycling. There are only a few indicators in the previous frameworks that refer to this. For example, the indicator on the reuse of WEEE in the monitoring framework of the European Union (European Commission, 2018) and two indicators in the French one on the level of spending on households due to maintenance and repair services, and in

car-sharing (Magnier et al., 2017). The material and energy-saving potential of such aspects of the circular economy are much greater compared to that of recycling (Potting, J., 2017).

Considerations for monitoring the Circular Economy:

The Circular Economy is a multidimensional model, for this reason, the decision must be made to conceive and develop it as a comprehensive and systemic frame of reference, and not limit it to a battery of indicators only.

> *'Monitoring for Flanders, with an eye to Europe', means that as policymakers and key actors in Flanders primarily interested in monitoring the transition to the Circular Economy, the need for a regional approach becomes evident. However, designing a monitoring framework applicable only under Flanders conditions may not be entirely desirable. There are several benefits to the Circular Economy that are correlated both to take advantage of Flemish data and initiatives and to connect with the interregional and international scene.*

Also, the Flemish economy is open: there is a great activity of import and export in material flows. This is thanks to the large size of the Flemish industrial sectors, the number of companies that operate at an international level, and the small size of the territory. This reality should be reflected in the framework of reference, to guarantee the recognition of the efforts of companies operating inside the parameters of the international Circular Economy.

A framework of this nature has a vision of how this transition should be understood, and it contains a reflection of the political vision of this long-term development model.

Circularity and its effects

This framework is centered on the product and also the result of the transition towards a Circular Economy. The **first focus deals with the products and materials** that are kept at their highest level of application (for example, through the flow of materials, closure of cycles, an extension of its lifetime, the efficiency of cycles). **The second one deals with associated impacts. In terms of sustainability, it is important to include performance indicators that provide clarity about the economy, the environment, and society, to have a more balanced vision.**

The macro-level: measure at a Flanders level

Some macro-indicators relevant to the Circular Economy have been developed in other contexts and are in use, for example, the flow of raw materials, their consumption, waste generation, etc. It is also important to comprehend that there are different perspectives already available like:

- The **consumption perspective**, focusing on the footprint of our material demand and the associated impacts, therefore, includes the parts of the chains outside the regional borders.
- The **territorial perspective**, focusing on the use of materials and the impacts within our borders.
- The **production perspective**, including what is produced in Flanders for other parts of the world.

Micro-level: products and services

Since the Circular Economy consists of keeping products and materials in circulation as long as possible and with the highest added value, for good monitoring it must reflect what happens at the level of products and materials. Also, there are three additional reasons to add this level within the reference frame:

- Progress towards the Circular Economy implies a transition that will require innovation in the design of products and services. Therefore, at this level, this innovation is essential to materialize the transition rather than at a macro-level.
- For the transition to happen, the government should intervene and reflect this in public policies. In the first place, the effects of these measures will become visible at the product and service level
- The challenge in monitoring transitions is that in the early stages, thanks to the small scale of the initial activities, these are not visible. The transition is already in the next stage when they have scaled enough.

It is important to mention that products and services usually cannot be seen separated from each other. In most cases, a service is associated with a product and vice-versa. There is a gradual scale between products and services; If we take a car as an example, we approach it as private property (if the focus is on the product, there are some associated services, such as maintenance service) or as a mobility service model like as a shared car (the focus is on the service, but there is still a car involved).

Meso-level: The link between the mico and macro

The present study described the challenge of linking the micro and macro levels, making clear the importance of developing a link between the micro and macro levels (Vercalsteren, A. et al., 2018):

• From the data provided by the available macro-indicators, disintegration is partial and the level of detail available on the data limits it.

• A bottom-up approach could add product and service data, but this is not realistic if it is not done in a detailed manner. Furthermore, by adding data, the question of how to deal with systemic dynamics is not solved

In terms of Circular Economy, monitoring at the meso level has been represented as follows:

- In the Dutch monitoring system, the set of macro-level indicators has been disaggregated into five sectors to align it with the monitoring of the separate sectoral agreements, carried out in the Netherlands for the transition of the Circular Economy (the so-called 'Grondstoffenakkoord').
- Alternatively, the meso level serves to establish a bridge in the monitoring of eco-industrial systems and industrial symbiosis networks (Ghisellini, P., 2016). Factories that connect to a grid concerning raw materials and energy are a desirable evolution in terms of the transition of the Circular Economy, and in the context of a nation with a rapidly growing industrial sector, monitoring this aspect. it is very relevant.

The Netherlands Environmental Assessment Agency showed that **understanding the role** of products and services is essential to provide clarity on possible strategies to reach the Circular Economy since it allows us to consider the most disruptive innovations fluidly.

An example of this approach was recently published (Materials Economics, 2018): In this report, the focus is on the potential role of the Circular Economy in mitigating climate change, where the authors claim that the potential to curb the climate crisis Through the Circular Economy can only be fully evaluated if the role of circular business models is included in the measurement. Thus, **together with the emissions caused by the use of the material and the efficiency of the material of the product, they have added a third element in their predictive analysis considering the amount of service delivered by the products.**

The link between macro and micro levels

The theory of managing the transition to the Circular Economy provides a series of steps to build the reference framework (Geels, F.W., 2002). In this theory, the transition space is divided into three layers:

• **THE LANDSCAPE:** This shapes the level of society, where changes usually gradually (unless they are extreme events). We could see this level corresponding to the macro level in our Circular Economy reference framework.

• **THE REGIME:** This is the level of culture (and the required cultural change in behavior). It is made up of broad domains of habits and customs, which determine the "normal" manner of doing things in society. From a Behavioral Economics perspective, it is aligned with the transformation of the consumer markets and, therefore, with the productive systems. Regulatory and mandatory frameworks are the determining mechanisms for changes in consumption and production patterns, as well as in the relationship between producers and consumers.

• **THE NICHE:** This is the level where islands of experimentation co-exist. The space to test new types of products and services. Is where innovation takes place on a small scale, concerning technology and the way of doing business. This could be the micro-level in our frame of reference.

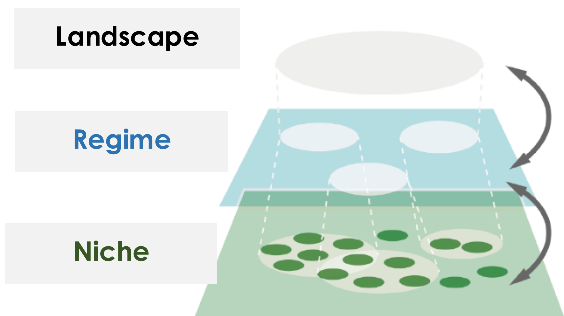


Figure 7: Transition space, adapted from Alaerts, 2020.

As the general denominator of such systems, we have chosen the perspective of meeting social needs.

The economy itself can be defined from a fundamental point of view as a way to satisfy our needs. Concerning the Circular Economy, this means that how we use products and materials to satisfy our needs will have to be drastically changed. Understanding the interaction between satisfiers, needs, and economic goods allows us to reconsider how the economy should be re-defined and, more specifically, the consumer market.

- In the year 2018, the "circularity gap" report (Wit et al., 2018) was published, which describes the global consumption of material, not only in general but also at a deeper level in what the authors describe as key social needs. The report uses a set of needs, such as housing, nutrition, and mobility, to map the resource footprint behind these needs.
- In another source, the term life functions have been used as a way to analyze sustainable consumption problems (Hertwich, E., 2003). The list is very similar to the needs described in the previous report: housing, mobility, nutrition, clothing, health, and leisure. The idea of the concept "life functions" can be seen as components of lifestyles, fulfilled by the consumption of products and services.
- In the context of the Asia-Pacific low-carbon lifestyle challenge, several drivers of consumption have been listed in the detailed explanation on the initiative's website (OECD, 2018). The needs addressed are food, home, goods, transportation, and leisure. So, creating sustainable lifestyles consists of rethinking the way of satisfying needs, in which consumption is a central part.
- The European Union has developed the product basket indicators within the context of measuring the consumer footprint (Notarnicola, B. et al., 2017). For this purpose, consumption has been divided into five key areas: food, housing, mobility, household items, and household appliances. These indicators offer composite scores based on Life Cycle Analysis data obtained from extensive samples of products available on the market.

As this new development model has a clear intersectoral nature, the consumption perspective is expected to be more accurate compared to a monitoring perspective based on the productive sector.

The following criteria could be relevant to arrive at a new selection of possible systems for monitoring the Circular Economy to be developed:

- Quantities of products and materials consumed.
- Size of associated impacts.
- Size and rate of the changes required in the context of the transition to the Circular Economy.
- Part of the cycle that takes place within the borders of Flanders.
- Importance of the associated industrial sectors in Flanders.
- Link to important political domains and strategies, and potential to have an impact through Flemish politics.
- Socio-cultural importance in Flanders-
- Alignment with the Sustainable Development Goals.
- Availability of data.

2.4. Indicators for a Circular Economy (State-of-the-art, 2020)

The inventory is based on scoreboards and monitoring frameworks developed by the European Union and by reports from the Joint Research Center (JRC) of the European Environment Agency (EEA). The list is complemented by indicators known to the authors (Vercalsteren, A. and Alaerts, L. et. Al., 2020) and exhaustive bibliographic research. This is a first step towards the development of a Circular Economy index for the Flanders region, which is one of the objectives of the Circular Economy Policy Research Center (formerly SuMMa Center).

The indicators related to the Circular Economy can be classified according to different criteria. To have an overview of some important characteristics of the evaluated indicators, they are classified into three axes:

- Micro, meso, macro levels
- Circular Economy Strategies
- Technology vs. socio-institutional vision

A first observation is that the existing indicators focus on physical parameters (such as kilograms), more related to technology.

Indicators that focus on socio-institutional aspects (for example, collection systems) are less defined and less frequently included in monitoring systems. The same is true for high-level circularity strategies. Very few indicators capture the effect of strategies related to the use and manufacture of products that are smarter and have a longer useful life, components, and the materials that make them up.

A transition towards a Circular Economy may not only be viewed from a material perspective but must include other environmental impacts such as climate change. Indicators that monitor environmental impacts already exist and can be easily combined and integrated into a set of indicators that allow evaluating the progress of the transition to the Circular Economy

How to measure an indicator?

In addition to the quantitative estimation of the indicator value, there are several options to relate this value, which can be related to:

- **Economic product:** For example, GDP (national or regional) and value-added that provides information on productivity (GDP in the numerator) or intensity (GDP in the denominator) of the economy or the economic activity sector.
- **Figures per capita:** These relate the value of the indicator to an average inhabitant or household. Per capita figures allow comparison between cities, regions, or countries, avoiding the problem of country size and population.
- **Input indicators:** For example, the domestic material input or the raw material input describes the materials mobilized or used to sustain economic activities, including the manufacture of products for export. They are closely related to the mode of production in a particular country or region and are sensitive to changes in the level and patterns of foreign trade or other factors such as a country's natural resource endowment and its level of technological development.

- **Output indicators:** For example, the "output of processed material" describes the output of material related to the production and consumption activities of a given country. They represent those materials that have been used in the economy and subsequently leave it in the form of discarded emissions and resources or the form of exports.
- **Consumption indicators:** For example, the use of "raw or household materials" describes the materials consumed by different economic activities. They are related to the type of use but are stable in time. The difference between "consumption" and "input" indicators evidence the degree of integration between the local and the global economy. When there is a big difference, the economic integration related to export can be considered bigger. This also depends on the size of the economy.

Regarding the calculation of GHG emissions, the State-of-art of Sustainable Development Metrics defines three ways to measure them:

- **Ecological Footprint of Consumption**[5].
- **Territorial emissions.**
- **Production emissions**.

The **Ecological Footprint of Consumption** uses the consumer perspective from all national consumption, including direct or use emissions (that is, during the use of the final product), emissions from domestic production upstream (indirect), and emissions from foreign production (import).

Territorial emissions are the sum of national direct emissions or emissions by consumers, the emissions of national companies in the production processes of products for local (indirect) consumption, and foreign consumption (export).

Production emissions focus only on the emissions of national companies in the life cycle of products for local consumption (indirect) and foreign consumption (export).

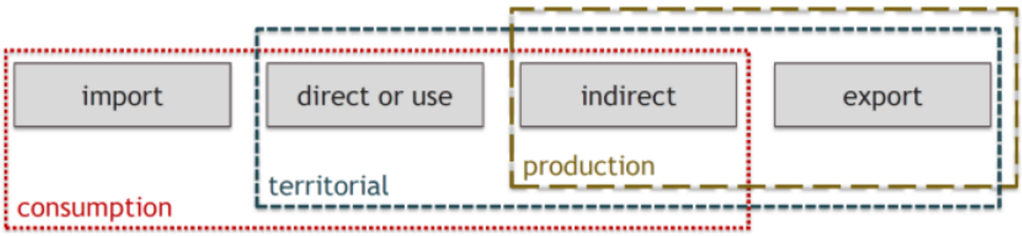


Figure 8: GHG emissions calculation according to the defined scope, source: Velcasteren, 2018.

To track the impact on GHG emissions through the implementation of Circular Economy strategies, a two-way approach is required:

[5] The Ecological Footprint of Consumption is a measure of how much area of biologically productive land and water an individual, population or activity requires to produce all the resources it consumes and to absorb the waste it generates, using prevailing technology and resource management practices, it is generally measured in global hectares. Source: https://www.footprintnetwork.org/resources/glossary/

- On the one hand, the focus is on mastering the **ecological footprint of consumption**, since changes in consumption patterns (for example, reduction of food waste) or production patterns (for example, greater reuse Packaging) changes the global production network and impacts global GHG emissions linked to local consumption.
- On the other hand, the focus is on **territorial emissions**, since with an increase in local activities related to the Circular Economy, it could also increase territorial emissions.

A comparison between these two indicators provides relevant information on the **impact on local and global GHG emissions and the distribution of benefits and costs among the regions**. An example of Flanders is presented in **Figure 9**.

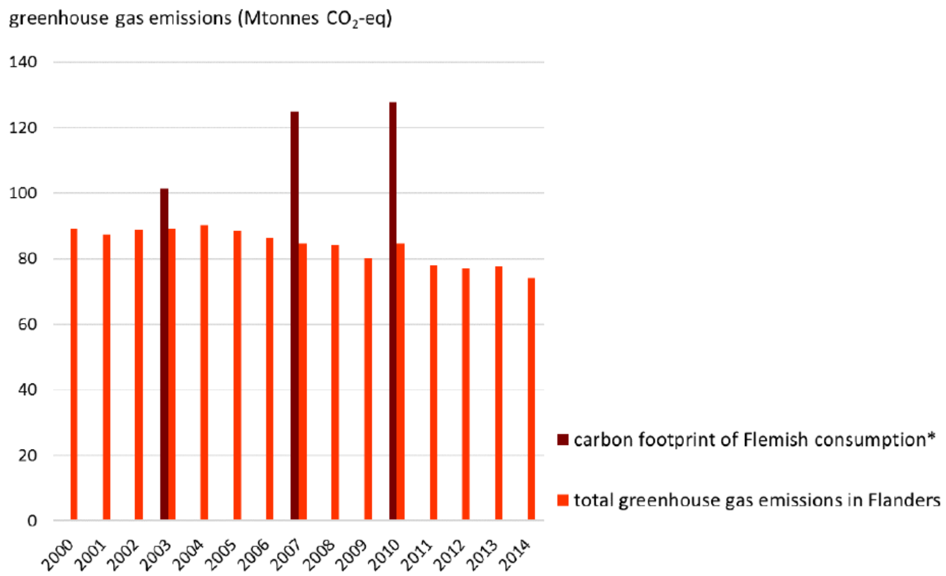
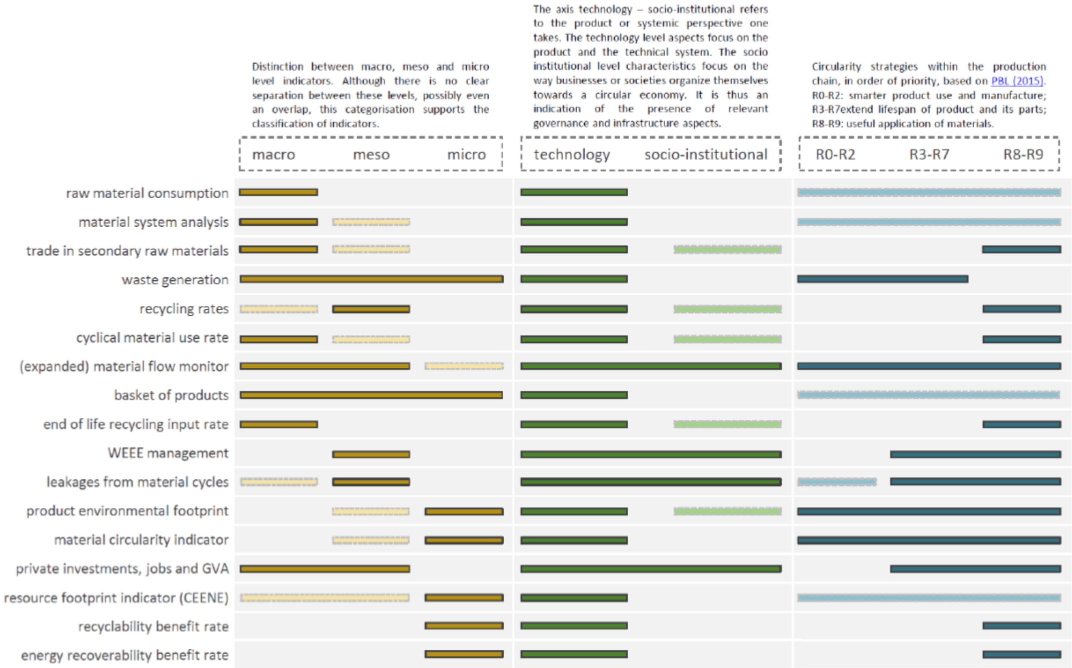


Figure 9: A comparative example of the ecological footprint of consumption and territorial greenhouse gas emissions in the Flemish region. Source: Vercalsteren et al., 2018.

The schematic structure of the monitoring framework and open data system for the Flemish region is presented below:

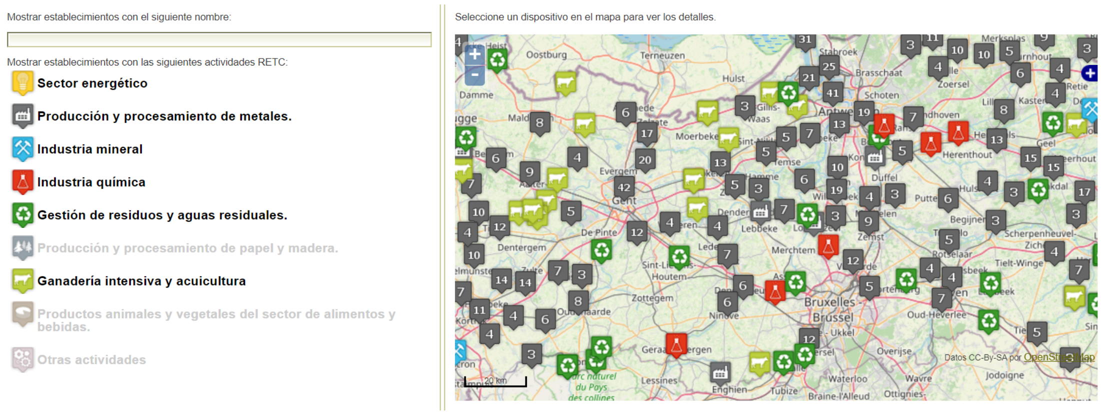


* CE strategies: the 10 CE-strategies according to PBL (R0 – R9) are used as a reference (Potting et al, 2017).

Figure 10: Scoreboard under three criteria Source: Vercalsteren et. al., 2017

This framework allows identifying the impact by level, the evolution on emissions due to local/global consumption patterns, in connection with the impacts generated by circularity strategies deployed on specific sectors, value-chains or territories.

Finally, the images show the geo-location of the industries in the region and through which the different monitoring indicators are reported to check the progress of the roadmap of the Circular Economy. These include the more significant for the authorities in charge of the monitoring of the achieving of the goals.



Emisiones de aguas residuales (en kg / año)										
Contaminante	2010	2011	2012	2013	2014	2015	2016	2017	2018	Acciones
Carbono orgánico total (TOC) (como C total o DQO / 3)	220000	203000	192000	211000	192000	167000	236000	207000	215000	
Cloruros (como Cl total)	3050000	2960000	2910000	3170000	2580000	2550000	3730000	3980000	3440000	
Cromo (Cr)					84,8	81,6				
Zinc (Zn)	1120	884	1450	907	707	743	1020	989	943	
Cobre (Cu)	288			869		54,7				
Nitrógeno total	166000	185000	167000	187000	150000	97500	145000	181000	171000	
Cadmio (Cd)					8,80					
Arsénico (como)	19,0	9.08	10,5	25,8	14,6					
Níquel (Ni)	46,9				26,6		32,7	51,2	54,6	
Fósforo total	25900	19400	22700	23500	19500	16000	22500	24800	19700	

Figure 11: Geolocation of industries and monitoring system of impacts and indicators[6]. Source: Pollutant Release and Transfer Register [PRTR] https://prtr.eea.europa.eu/.r

2.5. Monitoring Framework for the Circular Economy of the European Union

The European Union (EU), under the premise that "a circular economy aims to maintain the value of products, materials, and resources as much as possible by returning them to the product cycle at the end of use, minimizing the generation of garbage", has proposed a **framework of 10 indicators** focused on four areas (European Union, 2018) (See figure 12):

- **Production and consumption:** In this framework, these two factors are considered to be the first steps in developing a circular economy. Both the industrial and service sectors, as well as households, are expected to reduce the amount of waste generated and, in the long term, allow the European Union to be self-sufficient in the provision of certain raw materials. This area includes 4 indicators:
  - Self-sufficiency of raw materials for production in the European Union.
  - Green public purchases (as an indicator of financial aspects).
  - Generation of garbage (as an indicator of consumption aspects).
  - Food waste.
- **Waste management:** This framework considers recycling to be another step in the transition towards a circular economy, and the objective is to increase the

[6] State Registry of Emissions and Pollutant Sources. This monitoring framework and open data system is presented as a reference system in the event that countries decide to develop a similar Portal to integrate their indicators and monitor progress and impacts during the implementation of the Circular Economy Roadmap.

amount of waste that is recycled and returned to cycles within the economy to generate additional value. Two indicators have been proposed for this area:

  - Global recycling rates.
  - Recycling rates for specific materials (packaging, organic waste, electrical and electronic waste).

- **Secondary materials:** This area focuses on the measurement of the closure of the materials cycle. This cycle closure means that fewer virgin raw materials would go in the processes because of the reintroduction of recovered materials. Two indicators are proposed for this area:
  - Contribution of recycled materials to the demand for raw materials.
  - Trade of recycled raw materials among the member countries of the European Union and abroad.
- **Competitiveness and innovation:** The circular economy is considered to contribute to the creation of new jobs and economic growth. Also, it involves the development of new technologies that improve design to easily re-incorporate materials at the end of use, as well as promoting the generation of innovative industrial processes. Two indicators have been proposed within this area:
  - Private investments, the number of people employed, and net added value in sectors of the circular economy.
  - Patents related to recycling and secondary materials as an approximate measure of innovation.

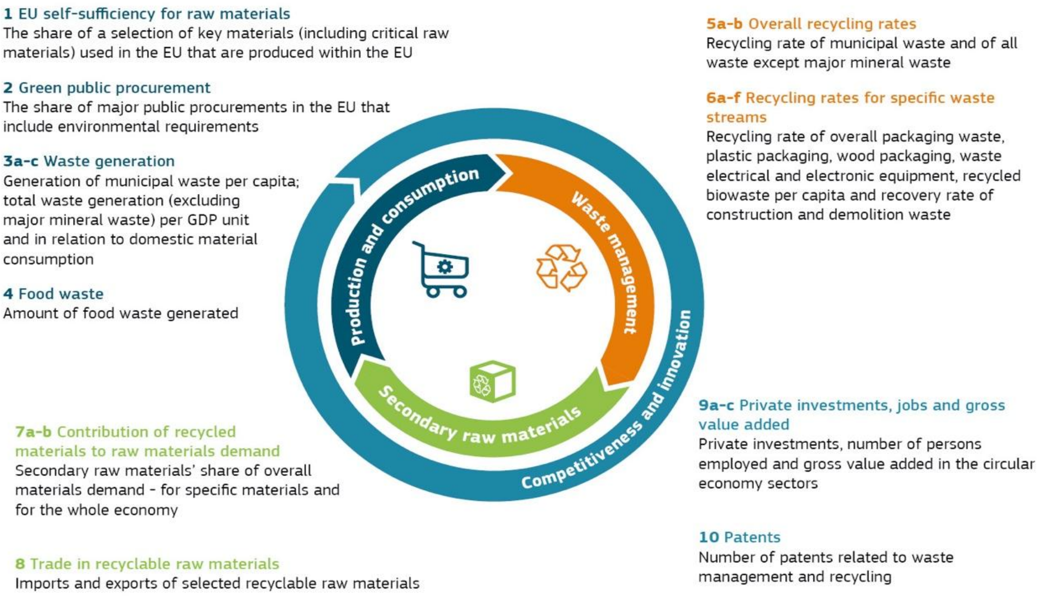


Figure 12: Monitoring framework of the Circular Economy in the European Union, Source: Eurostat

<u>Circular Materials Use Rate (CMU)</u>

This indicator measures the percentage of material recovered and reincorporated into the economy, thus avoiding the extraction of virgin raw materials. It is defined as the ratio of the use of circular materials to the total use of materials. The European Union defined the Circular Materials Use Rate (CMU)[7] as one of the main indicators to report progress both in the framework of circular economy presented in the previous section and the performance of Sustainable Development Goals (SDGs), specifically SDG12-Responsible Production and Consumption and the goals established for the generation and treatment of waste (European Union, 2019).

The European Union calculates this indicator following these equations and approximations:

$$CMU = \frac{CircularMaterialUse}{GlobalMaterialUse}$$

$$CircularMaterialUse = Amountofrecycledwasteindomesticplants + Amountofwasteexportedforforeignrecovery - Amountofwasteimportedforrecovery$$

$$GlobalMaterialUse = Consumptionofdomesticmaterials + circularmaterialsuse$$

A higher CMU value means that more secondary (circular) materials are replacing virgin raw materials, thereby reducing environmental impacts produced by material extraction.

A detailed explanation of the CMU calculation methodology is described in the report "*Circular material use rate: Calculation method*" published by Eurostat.

2.6. Recommendations from the Ellen MacArthur Foundation

The work of the Ellen MacArthur Foundation is to facilitate the circular economy at the country level. In its report *'Delivering the Circular Economy: A toolkit for policymakers'* (Ellen MacArthur Foundation 2015a), provides some recommendations to take into account when establishing indicators that measure the level of circularity and that allow comparing the performance of different countries. In this report, they establish that the existing metrics do not cover all aspects of the circular economy such as re-manufacturing and repair initiatives, and others. However, for practical purposes, they suggest a series of indicators that could be useful to establish a baseline of metrics that show the progress of the transition from a linear to a circular economy. Below a description of these suggested indicators is presented, clarifying that this set of indicators is not complete, but it does take into account four key areas of the circular economy. Data is available for its baseline, as well as allowing comparison between countries in time:

- **Resource productivity (GDP / Kg Domestic consumption of materials):** This indicator has the advantage of the high availability of transparent data. One consideration to keep in mind is that Domestic Material Consumption (DMC) in the denominator of influence largely by the industrial structure in each country and does not necessarily reflect environmental costs.
- **Circular activities:** Within this type of indicator would be ideal to include the level of adoption of remanufacturing/repairing/sharing practices. Since this

[7] This CMU relationship is based on principles of circularity such as keeping materials circulating within economic circuits, conserving and even increasing their value. This indicator measures the relationship between recovered

information is generally not available, it is suggested to use **recycling rates** and the **eco-innovation index**[8] as an approximation.

- **Waste generation:** In this case, it is proposed to make a distinction between municipal solid waste and waste generated at the industrial level. Like the DMC, it is important to consider that these types of indicators are influenced by the industrial structure for the country.

- **Energy and greenhouse gas emissions:** These indicators shall show the participation of renewable energy in the country's energy matrix, as well as GHG emissions, taking into account that these indicators depend on the economic structure for each country.
  - Brazil: the agriculture, transformation industry (aeronautics, textiles, automotive, IT, and tourism, etc.), and the services are the engines of this centered on diversification economy.
  - Uruguay: the main sector of study is food, focusing on two of its productive chains, which are dairy and beef industries.
  - Chile: sectors such as mining, the aquaculture industry, the energy sector are some of those that we can mention, due to their economic importance and their level of socio-environmental impacts, concerning the sub-regionalization of the country.
  - Mexico: the most important economic sectors include the steel / metallurgical industry, the cement industry, the paper sector, the chemical industry, and the transformation industry such as the automotive and aeronautical industries.

[8] This indicator has been established only in the countries of the European Union to measure the performance of each of the member states in different areas of eco-innovation. More information at: https://ec.europa.eu/environment/ecoap/indicators/index_en

3. Relevant metrics to measure progress in Circular Economy in Brazil, Chile, Mexico and Uruguay

3.1. Reference Framework for the transition and implementation of the Circular Economy in Brazil, Chile, Mexico and Uruguay

This section defines the reference framework for the measurement and monitoring of the transition and implementation of the Circular Economy for the four countries of which this study is the object.

3.1.1.Regional context and development scenario for Latin America

According to data from de United Nations, by 2019, 55% of the world population lived in cities and urban areas, and they estimate that by 2050, this proportion will be close to 70%, which is why the development model will depend more on how urban growth, socio-environmental impacts, and economic development are managed in low- and middle-income countries. In global figures, it will be about 2.5 billion people who will move to cities, leaving rural areas. As it has been a historical trend, this demographic distribution will occur unevenly in both geographic and economic terms.

Nowadays, the areas with the highest presence of human settlements in urban areas by region are:

- North America: 82%.
- Latin America and the Caribbean: 81%.
- Europe: 74%.
- Oceania: 68%.
- Asia: 50%

It should be pointed out that although Asia is the region with the lowest urbanization rate (around 50%), its population represents 54% of the world's urban population.

According to World Bank data, the urban population in Latin America and the Caribbean reached 81% by 2018. It should be noted that Mexico is the country with the lowest rate (80%) of the four countries in the study, while Uruguay has the highest of all (95%) and where Chile and Brazil have an index of 88% and 87%, respectively. Considering also that the total population in the region will increase at a rate close to 20% by 2050, where the population growth of the four countries under study will be of the order of between 12% and 16%, we can anticipate that the economic model of development will be defined by activities in cities.

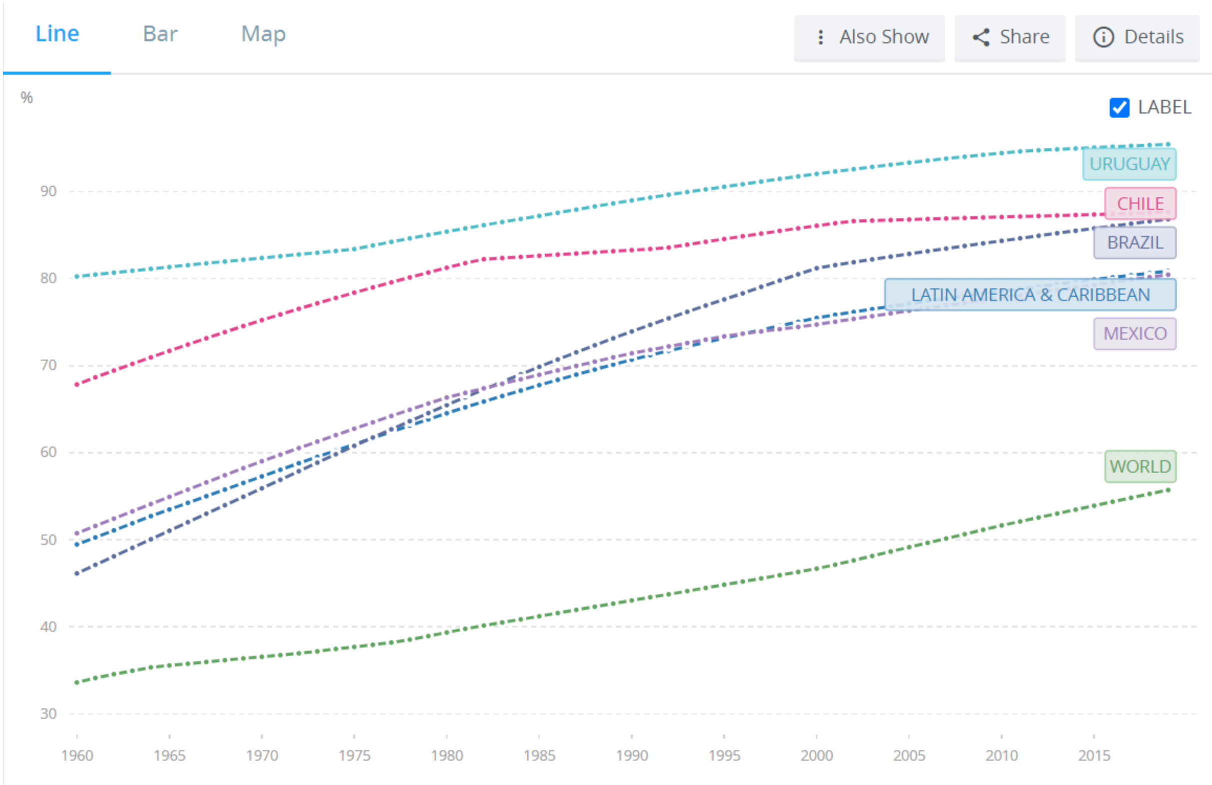


Figure 13: Urban population (% of total) in Latin America and the Caribbean and in the four countries that are the object of this study (1960-2019), Source: World Bank, 2020.

Mega and emerging cities

The mega-cities have populations greater than 10 million people or demographic densities greater than 2,000 inhabitants per square kilometer. Currently, there are 43 mega-cities in the world. 70% are located in Asia. In Latin America, there are 8 cities with more than 6.5 million inhabitants: Mexico City, Rio de Janeiro, Sao Paulo, Lima, Belo Horizonte, Santiago, Buenos Aires, and Bogota.

The projected growth trend is not focused on these mega-cities, although is where 30% of economic growth happens, and the most significant socio-environmental impacts are generated. It is in the 190 emerging cities (with a population close to 1 million people) where the greatest population growth is projected and where today 30% of the economic growth of the region with its respective impacts is generated.

Putting into perspective these statistics from the latest study by the *McKinsey Global Institute* on competitiveness in cities in Latin America and combining it with the projection of the urban population by 2050, we infer that urban areas will be called to transform their development models focused on the principles of the Circular Economy that guarantees the economic prosperity of the population, the regeneration, and conservation of natural capital and social welfare.

Initially, to achieve the Nationally Determined Contributions (NDC) and the Sustainable Development Goals outlined by the 2030 agenda, countries should leverage their national strategies in development plans and adaptation to climate change in cities, since are the spaces where the socio-environmental impacts result from the interaction of consumer markets and generate production chains. To achieve this strategic articulation, plans must be developed at the macro, micro, and meso levels.

From a perspective of the needs that will grow exponentially in these urban environments, we identify the massive development of housing, the transformation of mobility, the decarbonization of the energy matrix, the deployment of educational programs that incorporate a new paradigm and lifestyles associated with the Circular Economy and, according to the current situation, a robust healthcare system capable of ensuring public health conditions.

From a satisfactory perspective, innovation, research, entrepreneurship, channeling of resources towards technological development, of new circular business models and for the eco-design of products and new services will be urgent and necessary during the transition and implementation of a development model in Circular Economy that is duly supported by a regulatory framework focused on this purpose.

3.1.2. Circular and Sustainable Cities

Currently, cities constitute the largest centers of production and consumption, where nearly 75% of natural resources, 66% of the energy generated, and 54% of materials from the extractive industry are transformed into products and services that satisfy the needs of the market. Associated with this dynamic, cities are emitters of approximately 70% of GHG and the generation of 80% of solid waste that pollutes air, soil, and bodies of water (Ellen Mac Arthur Foundation, 2019).

Latin America generates about 160 million tons of urban solid waste per year and has a recycling rate of about 3%. Speaking of food production around 35% is discarded each year because of the market dynamics based on a linear economy. By 2050, it is estimated that 80% of food will be consumed in urban centers (FAO, 2019).

According to the projections of the 2019 World Economic Forum and the Ellen MacArthur Foundation, it is estimated that if a model of Circular Economy were adopted at a global level, the flow of materials avoided in extractive processes would be equivalent to a trillion dollars a year. The transition to circular and sustainable models has a mitigation potential of at least 20 million metric tons of urban solid waste per year, equivalent to 12% of that generated throughout Latin America (Ellen MacArthur, 2019).. If the adoption of the principles and technologies for the transition towards a Circular Economy model is attractive to the industrial sectors, it is the cities that have the greatest potential for use concerning all the opportunities that this model generates, since the deployment of infrastructure, equipment, and services, up to the enabling of industrial symbiosis mechanisms that transform the productive linkages towards sustainability.

According to World Bank data, municipal governments in developing countries must allocate between 20% and 50% of the annual budget to the urban solid waste management system, infrastructure that also generates very negative socio-environmental impacts by continuing to operate landfills (The World Bank Group, 2020).

In a context of transition towards the Circular Economy, material flows are re-incorporated into economic cycles over and over again, which on the one hand continues to generate value in production chains, but on the other hand avoids both the operating costs of an inefficient infrastructure, such as undesirable socio-environmental impacts for the community and natural capital. Other positive effects that are unleashed from this perspective are the creation of new jobs of higher quality, technological development, and investment in sustainable projects.

In recent years, some cities around the world have created strategies based on the Circular Economy at the municipal and metropolitan levels in alliance with neighbor municipalities, developing metropolitan land use plans for the medium and long term. This evidences the need for a regulatory framework that serves as an instrument of habilitation and support for the transition towards the Circular Economy. Some examples of those cities are London, Seoul, Austin, Amsterdam, Cape Town, Copenhagen, and Tel Aviv, and others.

As reference cities, we find that Malmö, Berlin, and Toronto. They have already implemented circular infrastructure design practices, which are expected to mobilize the intelligent and sustainable management of the natural resources and help the city to achieve the regeneration of the environment that guarantees access to the ecosystem services necessary for the coming years. For these cities, eco-design also promotes the recovery of materials once it reaches its useful life cycle.

Cities like Austin have developed platforms that allow the creation of new second-hand markets and more re-uses of the materials recovered through recycling chains. The Austin Materials Marketplace Platform facilitates the transactions and exchange of materials between companies within a new revaluation market. Since its inception in the years 2014-2015, the city has kept some 1,400 m3 of recovered materials in circulation, also avoiding the emission of almost 1,000 tons of carbon dioxide equivalent.

Milan is an iconic case of the transformation of the productive chains of the food sector, the city has mitigated the waste rate while the economic value of what was previously considered garbage or waste of the system has been recovered. Within the context of the construction of a regulatory framework that enables the collection and use of these discarded organic resources (Food Policy 2015-2020), they developed a collection model in schools, homes, and commercial establishments that are led to a digestion plant for the production of fertilizers for peri-urban agriculture and its energy used as biogas, which is injected into the city's energy network. The estimation is that since this policy was launched, the reduction in waste generation has been reduced by 17%, avoiding the emission of 9,000 tons of carbon dioxide per year.

3.1.3. Definition of the key elements of a Sustainable Circular Economy applied to the context of the four countries studied

To determine the criteria for selecting relevant indicators for the four countries analyzed in this study, it is necessary to establish a conceptual framework in which the key elements that define a Sustainable Circular Economy are highlighted. Eliciting this, the consulting team with experience in previous projects in the region, and considering the context of the countries included in this study, present the following definition of Sustainable Circular Economy, as well as the key elements that should be present in its development:

A **Sustainable Circular Economy** is intentionally designed to create positive benefits.

It is designed to create and maintain **regenerative and resilient territories** with positive results for everyone.

It creates **economic, environmental, and social abundance** in and around the territories, providing equality for the benefit of all species.

It achieves this **by perpetually circulating safe materials in biological and technical cycles**, powered by renewable energy, valuing clean water and celebrating diversity.

Definition developed by Kenneth Alston, 2019, and adapted by the consulting team of this project.

This definition arises from the establishment of seven key elements, which are considered fundamental for the implementation of Sustainable Circular Economy strategies in the countries studied in this project.

It is essential to clarify that not all Circular Economy practices achieve sustainability since in the circularization of processes externalities and negative impacts could be generated in light of sustainable development. An example of this is the introduction of recovered material flows that contain toxic substances from production and recycling chains that generate unwanted environmental impacts that could incorporate labor practices that are detrimental to the quality of life and well-being of those who operate it. For this reason, we have included this fundamental clarification, before continuing with our conceptual framework. In **Figure 14** these key elements are summarized and described:

Figure 14: Key elements of a Sustainable Circular Economy, adapted from the conceptual framework proposed by Factor/ASDF.

Element 1: Sustainability

Simply closing the cycle and re-incorporating unsustainable products and materials do not constitute a Circular Economy (CE), this means that CE is not automatically sustainable. In a Circular Economy model, products and materials can be collected, reprocessed, and resold at the end of their usage cycle. These processes can be carried out on goods and materials that are unsustainable in their first use. To develop a truly circular, restorative, and regenerative model, design principles must be introduced throughout the cycle of product use, in extraction, manufacturing, distribution, consumption or use, and reprocessing. Therefore, the three pillars of Sustainability: the economy, the environment, and society, must be taken into account to implement a Circular Economy model.

Element 2: Air and climate change

Climate change and air pollution are two of the main problems on the planet. Climate change is the global variation in climate that is accelerated by greenhouse gases caused by human activities. Air pollution is the presence of substances or particles in the air that imply a risk to humans and the natural ecosystem and derive mainly from the burning of fossil fuels (Sachs, J., 2015). To make it clear, contributing with solutions to the problem of global climate change and enabling compliance with the Sustainable Development Goals (SDGs) is an important strategic approach, where a Sustainable

Circular Economy is intentionally designed to create regenerative and restorative results in ecosystems that are natural and in sync with economic, environmental and social activities (Schmidheiny, S., 1992).

Element 3: Materials

A sustainable circular economy is designed with materials and products that can close the loop, for example, biological products or technical nutrients. We should reframe the idea of consuming and understand it according to the flow of materials. As costumers, we only actually consume the biological products (those who enter the biosphere), and those materials can be treated through strategies of the circular economy, however, most of the other products are used only to gain the service they provide but are not consumed. These products can be considered service-products and we could rethink the commercialization models like renting or others that stimulate the return and re-use.

Element 4: Energy

Both climate change and air pollution start from the same scenario: the current energy model. These two problems are enhanced by the burning of fossil fuels. A Sustainable Circular Economy operates with clean, renewable, low-carbon energy sources. These technologies must be designed to flow safely in the cycles of use proposed by the Circular Economy. The efficient use of energy, as well as the decarbonization of the economy, must be a strategic priority for all countries seeking to achieve universal and secure access to reliable and modern energy services (United Nations Assembly, 2017).

Element 5: Water

The effects of climate change become visible in the water in the form of droughts, floods, or storms. These disasters can devastate entire water supplies or contaminate them (UNICEF, 2016). A Sustainable Circular Economy values clean water and maintain its highest quality without negatively affecting water basins and natural water cycles. The proposal of the industries to change the linear model of using and purifying water for circular models should lean towards optimizing the use of water and abandoning the definition of wastewater (ANIA.es, 2018).

Element 6: Biodiversity

Climate change is one of the main pressures driving the loss of biodiversity in the world, in addition to the loss of habitats, overexploitation, pollution, and invasive exotic species. A Sustainable Circular Economy celebrates diversity by creating resilience and positive outcomes for all species. This means, for example, avoiding negative externalities such as the generation of pollutants and emissions of greenhouse gases. Thus, the protection of biomass, forests, oceans and other terrestrial, coastal and marine ecosystems as potential carbon sinks, which provide ecosystem services without interrupting their biological cycles, are elements that contribute to the mitigation of climate change.

Element 7: Community

A Sustainable Circular Economy promotes the social and fair development of the territories. This aspect is important in **emerging economies**, where the materials cycle closure activities have been carried out as survival means for vulnerable populations in societies. A Sustainable Circular Economy promotes and guarantees the creation of decent and safe working conditions for all people.

This conceptual framework with **seven key elements** serves as a reference to locate potential indicators to monitor the transition to a circular economy in the countries included in this study, which is presented in **section 3.2 of this report.**

3.1.4. Design of the Conceptual Reference Framework and Measurement and Monitoring System for the Transition and Implementation of the Circular Economy for Brazil, Chile, Mexico and Uruguay

Any reference framework for the measurement and monitoring of the progress of the Circular Economy must have a timeline with the transition stages and the scenarios in which it will be adopted by the various sectors involved, according to their level of influence for the economy of the country.

In the case of this project, we present below the conceptual framework on which the reference framework for the measurement and monitoring of the Circular Economy was designed in the four countries under study.

Time

This framework will have two stages:

- **Transition to the Circular Economy:** This first stage begins with the development of the detailed circular economy roadmap for each of the four countries (2020) and will end in 2030 with the evaluation of progress and results in alignment with the Nationally Determined Contribution (NDC) and with the goals of the 2030 Agenda for Sustainable Development (SDG).
- **Implementation of the Circular Economy:** Once the transition stage has been completed, and once the countries present a degree of evolution towards a sustainable development model, they will begin to measure and monitor progress and results aligned with the long-term goals that each country has been drawn up in the area of the circular economy, socio-economic development, mitigation and adaptation to climate change, innovation and implementation of industry 4.0 technologies[9]. This stage will be between the years 2031 and 2050.

Levels

According to the experience in countries where the Circular Economy has been implemented, this reference framework was structured based on three levels:

- **MICRO LEVEL:** Made up of all the products and services that allow defining the representative sample through which the patterns of production and consumption are characterized, both in the transition phase and in the implementation of the circular economy. The indicators of this level will be directly supplied by the companies and organizations that offer these solutions to the consumer market. It should be highlighted that these products and services will

[9] Industry 4.0 is a concept that should be understood as an enabling mechanism made up of the technologies of the Fourth Industrial Revolution applied to business, production and consumption models framed within the circular economy. These technologies increase industrial efficiency, the development of disruptive business models (circular), the development of new products and services under sustainability parameters, among others. In summary, Industry 4.0 is a main component of the circular economy roadmap for the countries that are part of this study (for more details, see Report 4). This document should be read together with all the reports that are part of this project, to have a global and long-term vision for the preparation, implementation and instrumentation of the Roadmap.

also be evaluated from the functionality they meet in solving the needs of the consumer, tracking the behavior, and its evolution over time.

- **MESO LEVEL:** This level is made up of indicators that group the results and impacts generated by economic sectors, production chains, and geo-located industrial parks in areas of influence where they have a direct impact. The main reason for defining this level of monitoring is focused on achieving advances and goals in particular systems that meet the needs of each country.
- **MACRO LEVEL:** At this level, the results of key indicators for the development of each country are compiled, which is why the focus is on the measurement of material, energy, and water flows, as well as the impacts associated with the fulfillment of commitments and goals. pre-established in socio-economic development strategies, mitigation, and adaptation to climate change. This will also give clarity to strategic decision-making on sectoral economic dynamics and for the import-export of raw materials, products, or services.

Factors:

An especially important property in this framework is to be able to determine which of these three characteristics links with which indicator that will measure both the progress of the transition and the implementation

- **TECHNOLOGICAL:** Defines the nature of the indicator and whether it measures the degree of evolution in technological development (for example the production of raw materials through value-added to resources recovered from a certain industry)
- **SOCIO-INSTITUTIONAL:** Defines the degree of impact where technology is not the protagonist, but where it plays a role as an enabler of said measured impact (for example transactions associated with the exchange of resources discarded through electronic commerce platforms that enable creating markets to extend the useful life of materials).
- **SHARED ECONOMY:** It defines the degree to which the actors establish collaborative links that modify the dynamics of production and consumption towards a circular economy model (for example the number of companies that supply and purchase the recovered raw materials or offer services that facilitate the use of assets under a shared economy model)

Layered Focus: Multidimensional and Staggered

Starting from the Principles of the Circular Economy that aim to keep the flows of materials and energy in use as long as possible, revalue them cyclically and promote production and consumption patterns that mitigate those negative socio-environmental impacts, also regenerating capital Naturally, this frame of reference is phased in the following degrees:

- **LAYER 1 - MATERIALS, ENERGY, AND WATER:** The first step of measurement and monitoring is the one that allows mapping the flows of materials, energy, and water. The objective is to visualize the inputs of all resources at each level (micro, meso, and macro) and the extractive or non-extractive origin of each flow, which allows evaluating the effectiveness of regulatory and strategic mechanisms in their use and/or dependence.

- **LAYER 2 - IMPACTS:** This step allows to know the socio-environmental impacts, the degree of socio-economic development and the progress concerning the goals pre-established by the National Development Strategies which, in turn, are anchored with the Sustainable Development Agendas and with commitments to mitigation and adaptation to climate change
- **LAYER 3: ENABLING MECHANISMS:** The third step refers to the mechanisms that block or enable the transition to the Circular Economy, among which are indicators that can be translated into the orientation of resources invested in innovation, in the development of technological projects, in the creation of companies and new businesses, as well as the impacts of public policies time by time.

Perspectives:

Taking up the contributions of the European Union reference framework, and complementing with our vision for the four countries that are the object of this study, the reference framework for monitoring the Circular Economy focuses on the following perspectives:

- **RAW MATERIALS:** Refers to the origin of the raw materials used in production, which can be of extractive or non-extractive origin (recovered materials) with which you can measure and monitor material flows, determine the degree of dependency of virgin raw materials and the level of impact of the mechanisms that enable re-exploitation dynamics in technical and biological cycles.
- **PRODUCT AND SERVICE DESIGN:** Perspective that puts the design of solutions and satisfiers (products or services) at the center of the economic model, focused on the re-incorporation of the resources used in new economic cycles.
- **PRODUCTION AND CONSUMPTION:** Oriented to the reduction of discarded resources during the transition stage and to the revaluation of the flows of materials, energy, and water, which close the cycles by re-defining the consumer markets and the relationship producer-consumer.
- **MANAGEMENT OF DISCARDED RESOURCES:** Through this perspective, it is verified that the resource flows that are discarded from the consumer market or other production processes are revalued based on the pyramid that determines the hierarchy of use of these resources (Directive 2008 -98-CE).
- **COMPETITIVENESS AND INNOVATION:** Refers to the contributions that the Circular Economy generates on the creation of new jobs, technological development, and economic growth.
- **GENDER PERSPECTIVE:** To achieve a model of Sustainable Circular Economy, the equity should be prioritized not only in terms of education or employment opportunities that any citizen can access but also the evolution of culture towards societies founded on values such as respect and empowerment of women and socially vulnerable groups under the current linear economy model.

- **RISKS AND IMPACTS:** This perspective allows us to establish a sensor of risk and of the impacts that could be unleashed by the occurrence of natural phenomena to which each of the four countries are exposed.

GHG emissions and black carbon[10]

A particularly relevant topic is that GHG emissions constitute the main objective of any decarbonization strategy of the economy, besides, to be the guiding axis of National Designated Entities (NDE).

National Designated Entities (NDE) have worked on their respective strategies for mitigation and adaptation to climate change focused on specific goals of GHG and black carbon emissions reduction, this can be under unconditional actions, and potential actions conditioned to be supported by international programs.

In the context of developing this reference framework for monitoring the Circular Economy, a measurement structure is proposed that is directly linked to the mentioned strategies and agendas, in the following scopes:

- **IMPORT:** Refers to the calculation of GHG emissions in the import processes of raw materials, inputs, and products or services, for the local market.
- **DIRECT:** This scope is defined by the GHG emissions generated directly by the companies and organizations that manufacture products or service providers**.**
- **INDIRECT:** Refers to GHG emissions generated indirectly by companies and organizations that manufacture products or provide services through their suppliers, distributors, and network of allies with whom they interact in the production chain.
- **EXPORT:** Refers to the calculation of GHG emissions in the export processes of raw materials, recovered materials, inputs, and products or services, for the international market.

Criteria

As it became evident in the state of the art of the reference frameworks developed for the monitoring of the Circular Economy in referring countries, for our case we have defined the following criteria on which the indicators that respond to the need for measurement and monitoring of results will be developed. Among them are:

- Quantities of products, materials, energy, and water consumed.
- Greenhouse gases emissions generated
- Size of the impacts associated with production.
- Size and exchange rate required for the transition to the Circular Economy.
- Part of the cycle that takes place within the country's borders.
- Importance of the economic sectors defined for the country.
- Link with national strategies and the potential to generate a positive impact in the country.
- Socio-cultural importance.

[10] After carbon dioxide CO2, it is the atmospheric pollutant that contributes the most to global warming. It is classified as a short-lived climate pollutant (CCVC). It is produced by activities such as the incomplete combustion of fossil fuels such as diesel, fuel oil or by the burning of biomass such as firewood.

- Alignment with the Sustainable Development Goals.
- Availability of data.
- Investment in innovation, entrepreneurship, and research development.
- Gender perspective.
- Negative impacts and/or externalities.

3.2. Selection of relevant transition indicators for the four countries

This section identifies a series of indicators that would allow evaluating progress in terms of Circular Economy in Brazil, Chile, Mexico, and Uruguay. As noted in section 2 of this report, it is important to highlight that indicators to measure a circular economy are currently under development, and some indicators that have been used globally to measure the Circular Economy may not reflect all the aspects considered by this paradigm. For this reason, the recommendations provided here have focused on proposing **Transition Indicators** based on the following premises:

- The stated indicators attempt to associate with the fundamental elements of the Circular Economy presented in this report (section 3.1). For this reason, the consultant team took into account **materials, water, energy, and community**.
- As presented in the **deliverable 2.4-Evaluation Report**, each country presents specific conditions and transversal conditions that can be attended from a Circular Economy perspective. Although the indicators that were proposed to compare the four countries have been focused on cross-cutting aspects, some of them are also proposed to consider the specific needs of each country. Some transversal aspects shall include:
  - The need to monitor the **mitigation of climate change** as a result of the circular economy initiatives developed in the four countries.
  - The need to include **social aspects** in the measurement of progress in terms of the Circular Economy, such as indicators that monitor gender equality.
  - The need to establish **enabling conditions** that allow the development of circular economy initiatives in the four countries.

Two sets of Transition Indicators are proposed: **(1)** a matrix with indicators for which it is possible to establish a **baseline**, since reliable and transparent information is available, and **(2)** a matrix with suggested indicators to be taken into account in the development scenario of a detailed **Circular Economy roadmap** in the four countries, these indicators do not currently have reliable and transparent information to establish their baseline.

3.2.1. Proposed indicators with baseline information

Among the indicators proposed in this matrix are those related to the management of materials and water, the incorporation of renewable energy sources into the national energy matrix, the carbon footprint generated, and the gender perspective agenda.

Table 1 presents as an example some of the indicators included in the framework presented as an attachment to this document. With this example, a description of the indicators and their relationship with the Circular Economy is provided.

Table 8: Matrix of proposed indicators with Baseline information. Source: Factor/ASDF, 2020.

Area	Indicator	Unit	Source[11]
Materials	**I1**. Municipal Solid Waste Generation [MSW]	Kg/day/per capita	SDG Report (Sachs et al., 2019)
	I2. Percentage of organic waste (food)	%	World Bank, 2018
	I3. Percentage of recycles MSW	%	World Bank, 2018
Water	**I4.** Percentage of anthropogenic wastewater treated	%	SDG Report (Sachs et al., 2019)
Energy and Climate change	**I5.** Percentage of renewable energy in the national energy matrix	%	SDG Report (Sachs et al., 2019)
	I6. Carbon footprint associated to energetic consumption	tCO_{2e}/per cápita	SDG Report (Sachs et al., 2019)
	I7. Vulnerability Index to Climate Change	1	Climate Change Vulnerability Monitor (The Hague Center for Strategic Studies, n/d)
Gender Perspective	**I8.** Percentage of managerial positions held by women in industry	%	Business chambers (economic sectors), World Bank, 2019b)

In the category of indicators related to ***materials management***, **three indicators** have been proposed, which are:

I1. Generation of municipal solid waste (MSW): This indicator has been proposed as a measure to monitor the production and consumption patterns of the countries. The Circular Economy proposes to eliminate the generation of waste, therefore, through current eco-efficiency practices, it is possible to optimize the

[11] For the purposes of the methodological development of this report, sources such as multilateral organizations and reports with global data were used. However, the countries will be able to present more precise data both in the elaboration of the baseline and in their time-to-time monitoring systems, provided that the methodology and compliance with the rigor in the declared measurement is clarified.

use of materials, and a reduction in the amount of waste generated is expected over times.

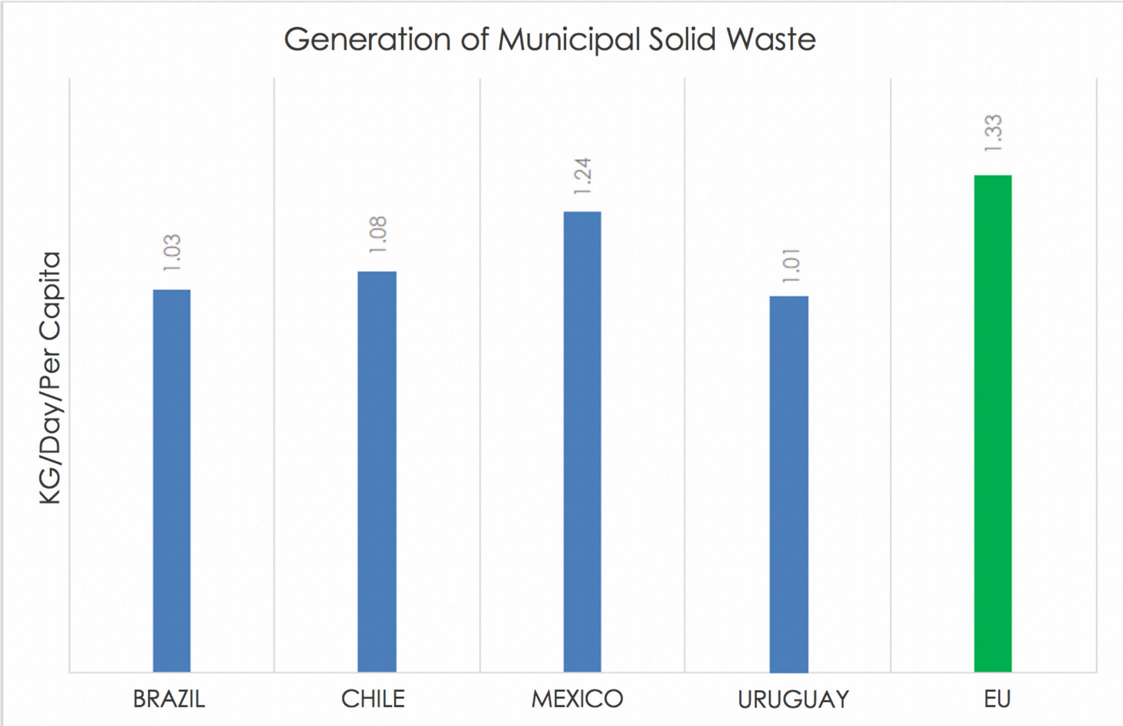


Figure 15: Municipal Solid Waste Generation [MSW], Source: Sachs, J. et al., 2019.

For a comparative analysis, reference information from the European Union was available for this indicator. As can be seen, in **Figure 15**, the generation of waste per capita in the four countries is below the value reported in the European Union, this is justified because the higher the purchasing level (case of Europe), it tends to consume more quantity and types of goods and services offered by the economies, leading to a greater generation of waste.

Also, according to SEMARNAT, Municipal Solid Waste Generation for Mexico accounts **0.944 kg/habitant/day in 2020**.

I2. Percentage of Organic Waste (food): Since the Circular Economy distinguishes technical and biological materials to establish recovery strategies[12], it is important to track the amount of organic (biological) waste that is being generated in the countries. This indicator would establish the baseline of biological materials that could potentially be used in the production of biochemical, energy, or compost. In the context of the countries analyzed, this information can be valuable, since the agricultural and food sector was prioritized in Brazil, Chile, and Uruguay.

[12] According to the Ellen MacArthur Foundation, "the circular economy model makes the distinction between **technical and biological cycles**, where food and other bio-based materials (e.g., cotton and wood) are designed to return to the system through composting and digestion processes. anaerobic. The cycles regenerate living systems, such as the soil, that offer renewable resources for the economy. **Technical cycles** recover and restore component products and materials through reuse, repair, remanufacturing or (ultimately) recycling strategies", since they are composite materials through industrial processes that do not allow their biodegradation (Ellen MacArthur, 2013).

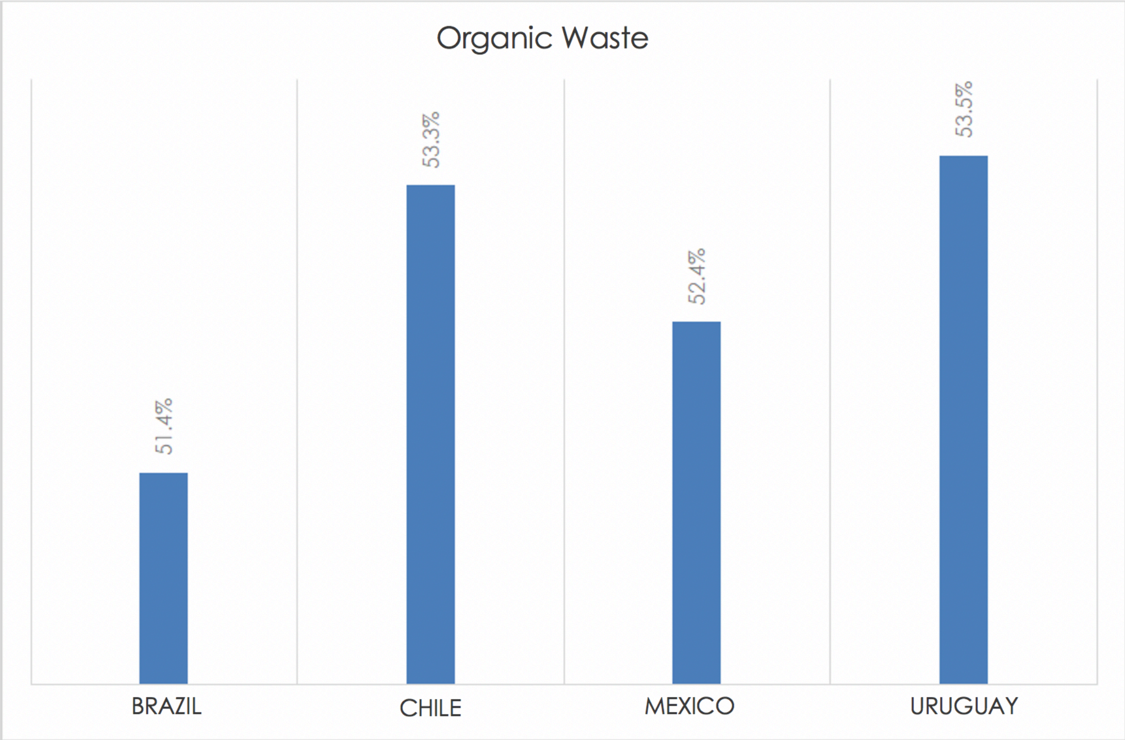


Figure 16: Percentage of Organic Waste (food waste), Source: World Bank, 2018.

Reference information was not available for this indicator and the data found for the different countries correspond to information available for 2010 for Brazil, 2009 for Chile, 2012 for Mexico, and 2003 for Uruguay. This comparative analysis was produced with information from the World Bank Open Data.

As observed in **Figure 16**, all the countries analyzed have a large fraction of organic waste subject to reincorporation strategies through the biological cycle of the Circular Economy.

Additionally, the National Direction of Energy in **Uruguay** have national values from 2013 where the percentage of **organic waste is 40.95% (LKSur, 2013)**. From the other side, **Mexico** has update information of the organic waste produced at a national level of **46.42% (SEMARNAT, 2020)**.

I3. The recycling rate of Municipal Solid Waste: In the current scenario, the recycling of materials is the most common circular economy practice and developed as a re-valorization practice (under a concept of down-cycling[13]), which has been widely documented in terms of numerical data, although this has not means that it is the only practice and the most cost-effective. Taking this into account, the following indicator is proposed in order to monitor the efforts of the countries to prevent valuable and usable materials from ending up in sanitary landfills or being disposed of in uncontrolled landfills, contaminating ecosystems and natural resources.

[13] Downcycling is a concept that refers to any model of use of a by-product, component or material that at the end of its life, does not find its re-incorporation in economic cycles of greater added value, but can be transformed into another product or inferior raw material. The benefit of the models associated with this concept is that they avoid the extraction of new virgin raw materials that are substituted by these new material flows, however, their processing requires energy and water consumption.

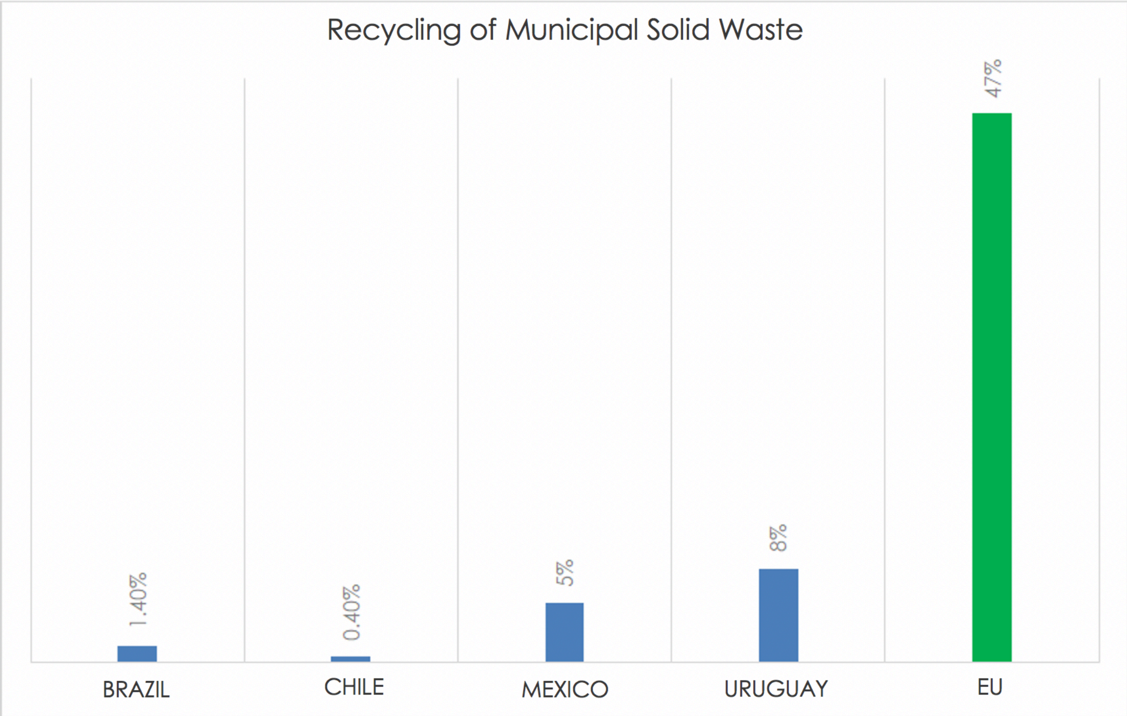


Figure 17: The recycling rate of Municipal Solid Waste (MSW), Source: World Bank, 2018.

For this indicator, we had reference information from the European Union (EU) for the year 2018, and the data reported for the analyzed countries correspond to 2014 for Brazil, 2009 for Chile, 2013 for Mexico[14], and 2011 for Uruguay.

As can be seen in **Figure 17**, the recycling rates of the four countries analyzed are considerably lower than those reported by the EU.

In the first instance, it is important to consider that recycling activities in the four countries are largely carried out by informal groups of "recyclers" and this may present some barriers to obtaining consistent information over time. On the other hand, this marked difference between the four countries and the benchmark of the European Union allows us to conclude that it is necessary to develop strategies at the regional level that facilitate the recycling of materials that have proven high recovery rates, for this it is necessary, for example, to develop adequate infrastructure for collection, classification, and treatment, as well as consumer engagement strategies through the adequate marking of materials.

An **indicator** has been proposed in the category of **indicators related to water** management:

I4. Percentage of anthropogenic wastewater treated: This indicator considers the percentage of wastewater that is treated by centralized wastewater treatment

[14] The 2012 "Diagnóstico Básico para la Gestión Integral de los Residuos" report presents the value of 9.6% as the recycling rate of Urban Solid Waste, based on specific studies. The 2020 version has not an updated value, (SEMARNAT, 2020), it maintains the current value of 9.6% as the recycling rate of Urban Solid Waste. This shows a significant difference with respect to the data shown in figure 17, which is based on 2013 but confirms the high potential for re-use that is still wasted 10 years after the last official measurement.

facilities. Given that there is currently no indicator that measures the circularity of water, that is the amount of water that is effectively reincorporated into the system for industrial or domestic consumption, by monitoring the percentage of treated wastewater it is possible to determine the capacity of countries to process water contaminated by anthropogenic effects.

According to data from the SDG 2019 index for Latin America and the Caribbean, published in 2020 by the Center for Sustainable Development Goals for Latin America (Sachs, J., et. Al., 2019) the indicator "Percentage of wastewater of human origin that receives treatment" reported for Brazil was 17.50%, for Chile, 87.51% and for Mexico, 45.63%. In the case of Uruguay, the National Environmental Observatory of MVOTMA-DINAMA recorded an index of 62.4% for this indicator in 2016 (MVOTMA. (2017)).

In the category of indicators related to **energy and climate change, two indicators** have been proposed:

I5. Percentage of renewable energy in the energy matrix: A Circular Economy is powered by renewable energy. As a first measure to assess progress in this regard, it is proposed to monitor the level of the energy transition towards renewable energy sources. It is important to note that any strategy to migrate towards renewable energies should consider the management of the materials used to provide these technologies.

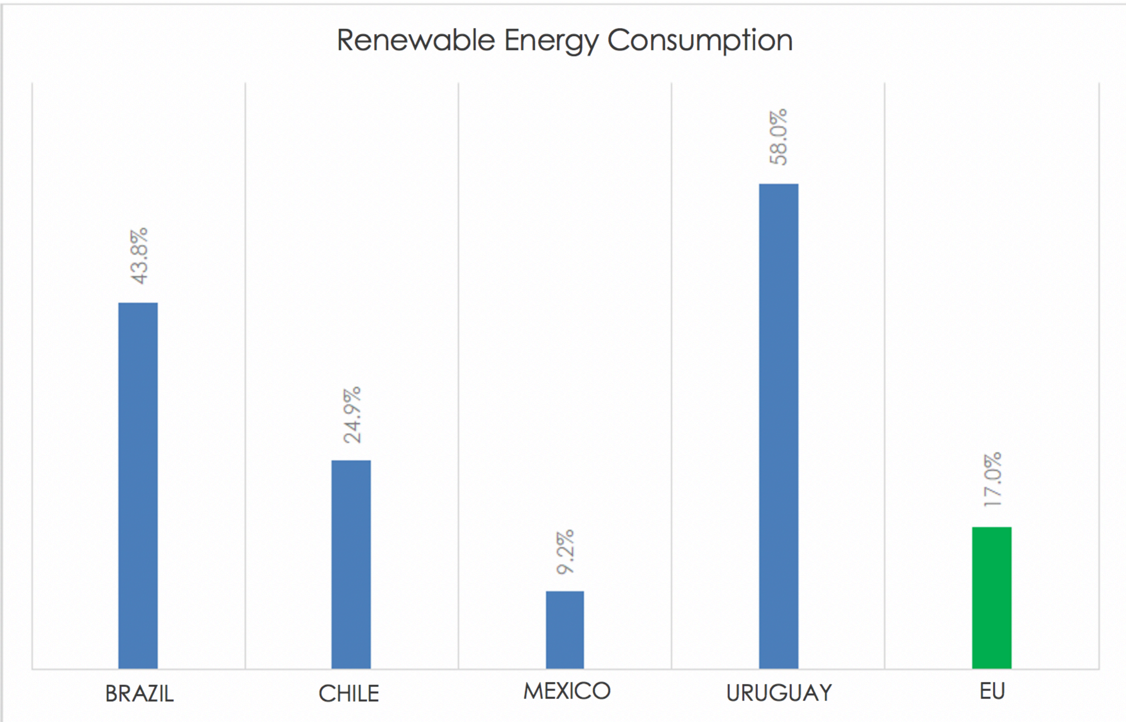


Figure 18: Percentage of renewable energy consumption (total percentage of renewable energy), Source: World Bank, 2019 and Sachs, J. et al., 2019.

I6. Energy-related carbon footprint: As mentioned in **Section 3.1**, the Circular Economy aims to eliminate negative externalities such as climate change. Monitoring of CO_2 generation is a first step to establish a baseline of information that could be optimized with circular economy practices in the respective countries. GHG emissions are due to the various activities that involve both energy consumption and other material and water resources, as well as the use of various natural resources such as soil, among others. For this reason, a specific indicator is proposed to allow estimating the carbon footprint associated with energy consumption in the entire production chain, in the consumer market and in the post-consumption of products and services. This indicator is closely related to the energy generation matrix of each country.

Next, the carbon footprint due to energy consumption in the four countries and a comparison with the indicator for the European Union is presented.

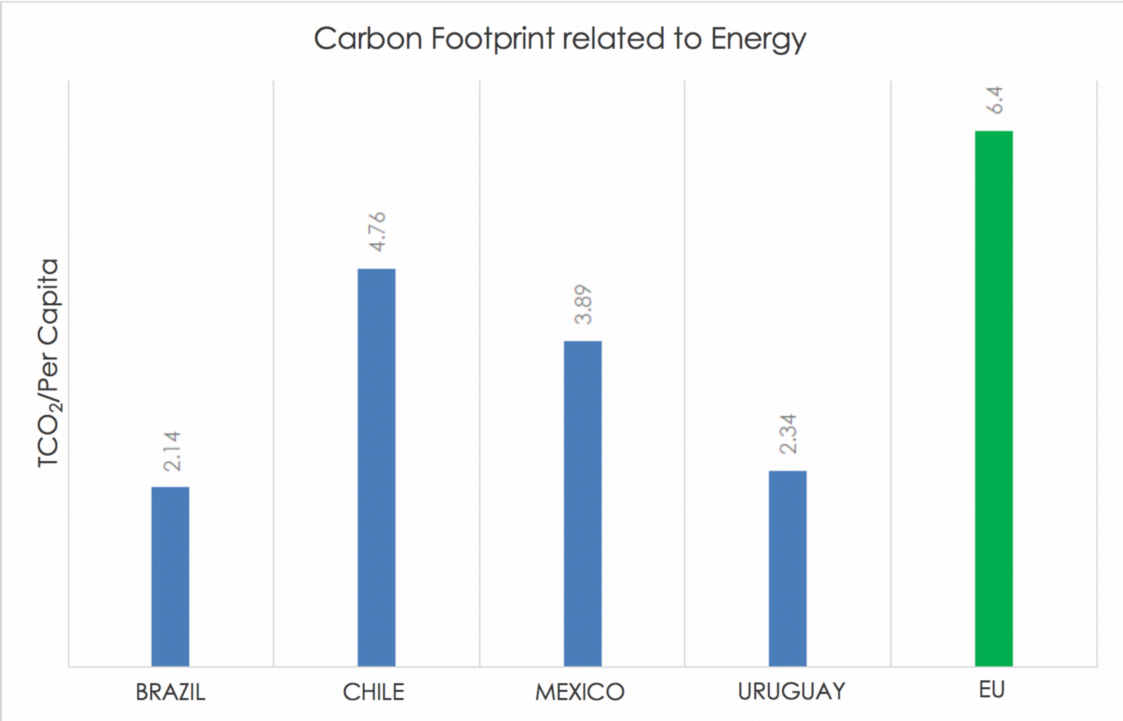


Figure 19: Energy-related carbon footprint, Source: Sachs, J. et al., 2019a.

I7. Climate Change Vulnerability Index[15]: Shows the relative value of various countries concerning the three greatest impacts of climate change: climate-disaster relationship, increased water level, and loss of agricultural productivity.

[15] As references, for Brazil, the AdaptaClima Brazil platform and for the case of Mexico, the National Institute of Statistics, Geography and Informatics INEGI, have robust databases on vulnerability.

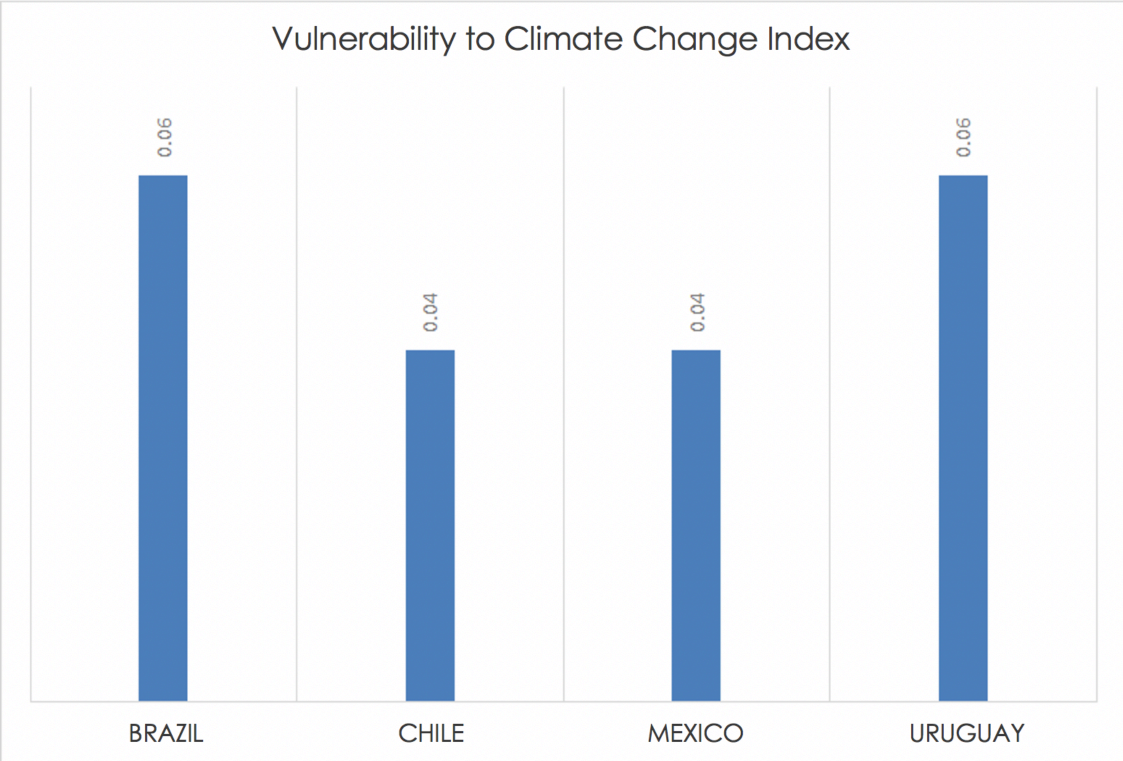


Figure 20: Climate Change Vulnerability Index, Source: Climate Change Vulnerability Monitor, 2012.

This proposed indicator has been taken from the DARA International Organization, so the country should take into consideration that if the monitoring is interrupted by this organization, the indicator will be compromised for monitoring time by time. In this sense, the aim is to define a vulnerability indicator that is fed with data from official sources of each country.

Finally, in the category of indicators related to social aspects, an indicator has been proposed:

I8. Percentage of managerial roles held by women in the industry: This indicator is proposed as the first measure to assess progress in the inclusion of women in leadership positions that require decision-making for the main economic sectors of the countries. It is important to highlight that it is required to generate strategies to measure the engagement of women in Circular Economy initiatives since there are no such strategies and information.

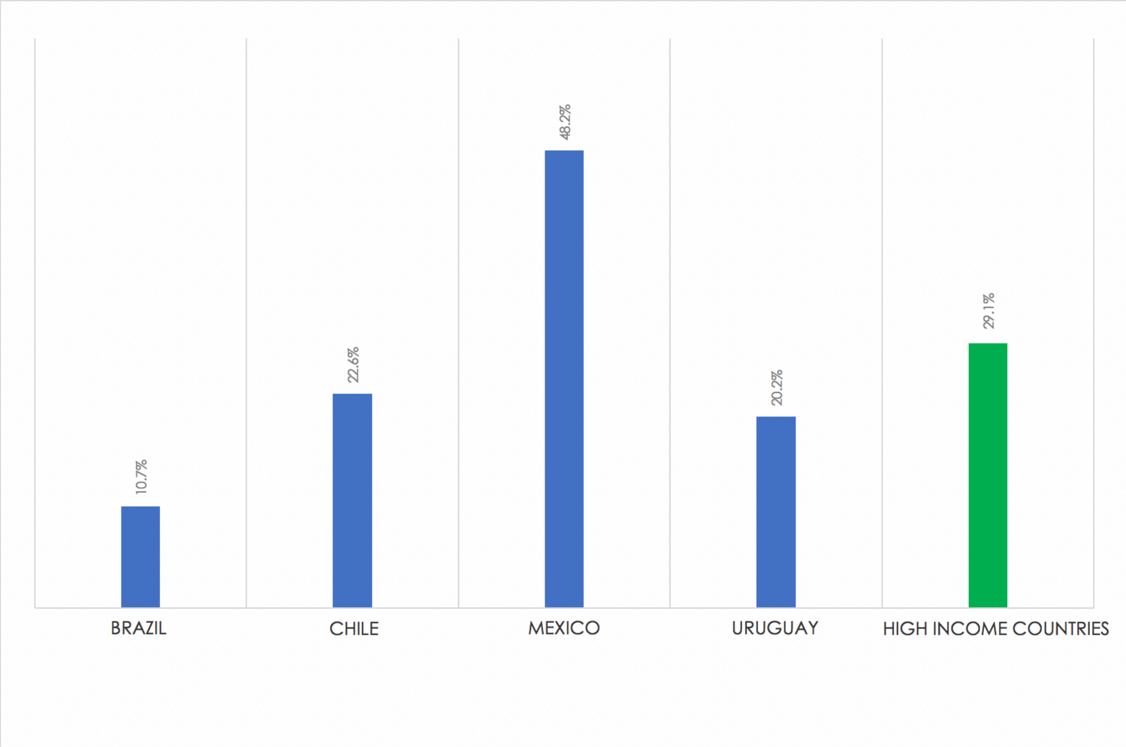


Figure 21: Percentage of managerial roles held by women in the industry, (Source: World Bank, 2019b).

3.2.2. Proposed indicators to be considered in the development of a detailed circular economy roadmap

The transition to a Circular Economy, as well as the development of a roadmap to achieve this transition, implies establishing new indicators that reflect the advances that nations make to achieve more circular, resilient, and sustainable economies, in addition to mechanisms to collect transparent information for the calculation of these indicators.

Considering the current information gaps, but also the progress that is being made worldwide to establish indicators that are comparable between different geographies, a series of indicators are proposed below that can reflect in greater depth key aspects of the circular economy. Besides, it is important to highlight that these indicators are suitable for a process of transition towards a Circular Economy since they measure variables in a scenario that is still operating linearly, but in which actions are being implemented to advance towards the circular economy.

Table 9 presents a list of the proposed indicators with their respective observations. These indicators are framed within the areas proposed in the matrix presented in **Table 8** (baseline). Additionally, within these categories shown as an example, a category was included that relates the enabling conditions for a Circular Economy since in a state of transition countries must act at different levels (investments, incentives, capacity building) to promote practices that accelerate the process of adopting a Circular Economy.

It should be carried in mind that the battery of indicators of the country reference framework must be aligned during the following three processes[16]: a) During the definition of the baseline that considers what can be measured in the preparation of the roadmap, b) during the entire process of transition from the current economy (linear model) to a circular model and c) At the stage of implementation of the circular economy where there will be sufficient data to feed multi-level indicators and concerning the most important aspects relevant to each country. Therefore, the importance of each NDE defining the indicators together with the sector leader.

*Table 9: Transition Indicators proposed to consider in developing a detailed circular economy roadmap *, Source: Factor/ASDF. *These indicators do not have baseline information at the moment, and it is necessary to develop mechanisms to obtain reliable information.*

Area	Indicator	Unit	Observations
Materials	**IP1.** Percentage of circular material use (CMU)	%	This indicator is proposed, which is already being measured by the European Union, as a mechanism to quantify the number of materials reintroduced into the economy to avoid the extraction of virgin raw materials. At the moment, there is no detailed information on the quantities of recycled materials and the import/export of materials to be recovered, for this reason, if the use of this indicator is considered appropriate, countries should establish mechanisms to have this information.
	IP2: Recovery percentage of technical and biological material	%	In the medium term, it is important to distinguish the material flows present in the economies, as well as the alternatives for their recovery. It is proposed to calculate recycling/recovery rates for specific materials such as packaging, food, and other streams that may be important to the country. Moreover, it is important to evaluate alternatives to measure other cycles proposed by the circular economy, such as the sharing of assets, the repair, and re-manufacturing of goods, among others.
Water	**IP3.** Percentage of water circularity	%	This type of indicator is being developed at the business level, seeking to establish the amount of water that is effectively reincorporated for use in companies and homes (WBCSD, 2020). It is important to establish mechanisms to have information at the national level to report

16 The indicators shown as an initial reference will be refined as part of the process of preparing the circular economy roadmap for each country, based on the data available from official entities.

			this type of indicators[17].
Energy and climate change	**IP4.** Reuse percentage of materials used in the provision of RE	%	The technologies used to provide renewable energy are subject to the development of strategies that allow the cycle of materials used in them to be closed virtuously. It is important to keep in mind that the circular economy has a systemic approach and that effective materials management must be present in the field of renewable energy.
	IP5. Carbon footprint avoided by circular economy initiatives	tCO_{2e}/ per capita	One of the main objectives of the circular economy is the mitigation of negative externalities such as climate change. Thus, it is suggested that the mitigation of climate change that takes place thanks to the strategies, actions, or circular pilot projects implemented in the countries be measured. The measurement of this class of indicators must be defined at micro, meso, and macro levels.
Gender perspective	**IP6.** Female percentage of ownership of companies / cooperatives destined for the Circular Economy	%	The inclusion of women at different levels of society is a developing issue on the regional agenda. It is important that these issues are considered fundamental in any circular economy strategy proposed at the national level, therefore it is suggested to implement this type of indicators to evaluate how gender inclusion is present in the development of a circular economy.
Enabling Conditions	**IP8.** Percentage of public procurement and tenders for circular economy systems (of the total)	%	Public procurement, and other government mechanisms, could undoubtedly facilitate the transition to a circular economy, for this reason, it is important to monitor these types of indicators, which are also already being implemented at the European level.
	IP9. Policies, regulations and financial mechanisms that support the Development of a Circular Economy in the country	#	Describe Policies, Regulations, mechanisms are contributing with the transition to CE.

[17] As a reference, the case of EUROSTAT is presented, where indicators of the 2030 Agenda (SDG6) are integrated together with a system of indicators of circularity, competitiveness, innovation and other aspects of regional development. Available at: https://ec.europa.eu/eurostat/data/database

	IP10. Number of professionals (M-F) trained for activities related to the Circular Economy.	#, %M-%H	The successful development of any circular economy strategy requires competent and trained professionals in the subject; therefore, it is proposed to explore indicators that show how progress is being made in the generation of capacities in the countries.

3.2.3. Proposed system of indicators – within the framework of reference for the measurement and monitoring of the progress of the Circular Economy in Brazil, Chile, Mexico and Uruguay

Finally, the structure of the measurement and monitoring system is presented through which the baseline can be defined for each country, monitor progress during the transition stage, and verify if the results achieved over time are in alignment with the Roadmap in Circular Economy designed for each context.

The master data file is attached at the end of this section.

The multi-dimensional layered approach is seen as follows:

- **Materials Entry** (Materials, Energy and Water)
- **Impacts** (Discarded Resources, Water, Impact and Climate Change, Competitiveness and Productivity, Economic Development, Gender Perspective, and Risk Management and Natural Disasters)
- **Enablers** (Sustainable Entrepreneurship, Sustainable Innovation and Industry 4.0 and Regulatory and Regulatory Framework for Sustainable Development of the Circular Economy and Industry 4.0)

The measurement and monitoring system timeline link the following:

- Measurement levels (micro, meso, and macro)
- The stages (Baseline, transition, and implementation of the roadmap in Circular Economy)
- 2030 Agenda (The SDGs directly related to the material issue and measurement indicator)
- NDC (the link with the contributions acquired by the country before the Paris Agreement)
- Responsible Entity (entity, institution or organization responsible for reporting time-by-time its indicators in charge)

Note: Due to the size of the dashboard (indicators and monitoring system), only an illustration is displayed in the following figure.

The complete dashboard for the four countries is available in the attached Excel file: **D3.4_EC_Monitoreo_KPIs_Dashboard_FINAL**

					2015-2020			2020 - 2030			2030		2031 - 2050		
					BASELINE (KPIs)			TRANSITION TO CE MONITORING					CE MONITORING		
	GENERAL TOPIC	SPECIFIC TOPIC	FACTOR	MATERIAL TOPIC	What should it be measured?	MICRO	MESO	MACRO	MICRO	MESO	MACRO	SDGs	NDCs	MICRO	MESO	MACRO
ENERGY, MATERIALS & WATER INFLOW	MATERIALS	VIRGIN MATERIALS	TECHNOLOGY	VIRGIN RAW MATERIALS	i.e. What kind of virgin raw materials are used in Brazilian Industry and how big are these materials flows?	Ton	Ton	Ton								
			TECHNOLOGY	VIRGIN RAW MATERIALS MATRIX ANALYSIS		Matrix	Matrix	Matrix								
			TECHNOLOGY	RAW MATERIALS FLOW - METALS		Ton	Ton	Ton								
			SOCIAL-INSTITUTIONAL	RAW MATERIALS FLOW - METALS [imports]		%	%	%								
			TECHNOLOGY	RAW MATERIALS FLOW - PLASTICS [imports]		Ton	Ton	Ton								
			SOCIAL-INSTITUTIONAL	RAW MATERIALS FLOW - PLASTICS [imports]		%	%	%								
			TECHNOLOGY	RAW MATERIALS FLOW - BIOMASS [imports]		Ton	Ton	Ton								
			TECHNOLOGY	RAW MATERIALS FLOW - BIOMASS [imports]		%	%	%								
		RECOVERED MATERIALS	TECHNOLOGY	RECOVERED RAW MATERIALS		Ton	Ton	Ton	CMU (%)	CMU (%)	CMU (%)					
			SOCIAL-INSTITUTIONAL	RECOVERED RAW MATERIALS [imports]		%	%	%								
			SHARING ECONOMY	RECOVERED MATERIALS SHARING PLATFORM		Ton/region	Ton/region	Ton/region								
	ENERGY	FOSSIL ENERGY	TECHNOLOGY	NATIONAL ENERGY MATRIX		KW	MW	GW	KW	MW	GW					
			TECHNOLOGY	ENERGY CONSUMPTION [by industry & region]		Kwh	Mwh	Mwh	Kwh	Mwh	Mwh					
			SOCIAL-INSTITUTIONAL	INDUSTRIAL ENERGY EFFICIENCY		#, $	#, $	#, $	#, $	#, $	#, $					
			TECHNOLOGY	OIL & GAS EXTRACTION		Ton	Ton	Ton	Ton	Ton	Ton					
			TECHNOLOGY	OIL & FOSSIL FUELS REFINING		Gal/day	Gal/day	Gal/day	Gal/day	Gal/day	Gal/day					
			SOCIAL-INSTITUTIONAL	INTERNATIONAL ENERGY MARKET		Bpd	Bpd	Bpd	Bpd	Bpd	Bpd					
			TECHNOLOGY	NATIONAL CONSUMPTION [by sector]		Gal/day	Gal/day	Gal/day	Gal/day	Gal/day	Gal/day					
		CLEAN & RENEWABLE ENERGY	TECHNOLOGY	RENEWABLE ENERGY PARTICIPATION ON THE NATIONAL MATRIX		%, KW	%, MW	%, GW	%, KW	%, MW	%, GW					
			TECHNOLOGY	RENEWABLE ENERGY CO-GENERATION [by Industry & Region]		Matrix	Matrix	Matrix	Matrix	Matrix	Matrix					
			SOCIAL-INSTITUTIONAL	CLEAN & RENEWABLE ENERGY CERTIFICATES		Matrix	Matrix	Matrix	Matrix	Matrix	Matrix					
			TECHNOLOGY	WASTE ENERGY CO-PROCESSING		Ton RDFs, KW	Ton RDFs, KW	Ton RDFs, MW	Ton RDFs, KW	Ton RDFs, KW	Ton RDFs, MW					
			SHARING ECONOMY	INDUSTRIES WITH CO-PROCESSIING FACILITIES		Matrix	Matrix	Matrix	Matrix	Matrix	Matrix					
	WATER	CLEAN WATER	SOCIAL-INSTITUTIONAL	CLEAN WATER RESOURCES & RESERVOIRS							m3					
			TECHNOLOGY	WATER SANITATION					m3	m3	m3					
			TECHNOLOGY	WATER NATIONAL MATRIX						m3/s	m3/s					
			TECHNOLOGY	RENEWABLE RATE [rain regime]						mm/year	mm/year					
			TECHNOLOGY	CLEAN WATER CONSUMPTION [by industry, region]					m3, m3/unit	m3/año/inhab	m3/año/inhab					
			TECHNOLOGY	CLEAN WATER CONSUMPTION PER CAPITA					lt/año/inhab	lt/año/inhab	lt/año/inhab					
			TECHNOLOGY	CLEAN WATER CONSUMPTION BY INDUSTRY [per production unit]					m3/production.unit	m3/production.unit	m3/production.unit					
			TECHNOLOGY	CLEAN WATER CONSUMPTION BY AGRICULTURE & AFOLU					m3/s	m3/s	m3/s					
			SOCIAL-INSTITUTIONAL	PROTECTED WATER RESERVES						m3	m3					

Figure 22: Illustration of the Circular Economy measurement and monitoring system for the four countries: Relevant aspects for measuring and monitoring progress. Source: Factor/ASDF, 2020.

It should be emphasized that the indicators must be developed strategically by each country, taking into account the most significant economic sectors, the agenda for mitigation and adaptation to climate change, and these may be expanded or modified over time, according to the level of maturity of the development model and the priorities outlined by the circular economy roadmap.

4. Conclusions and recommendations

Through the review of the state-of-the-art of the practices that allow monitoring the efforts to develop a Circular Economy, the development of a three-level frame of reference (macro, meso, and micro) was determined, by which sufficient information is obtained to monitoring the progress in the fulfillment of country commitments to the Paris Agreement and the 2030 Agenda, but also to monitor the stage of progress of the transition towards a circular economy from the productive sectors and at the regional level.

At the macro-level (country level), it was possible to propose a preliminary matrix of indicators for which information is available to establish a country and sectoral baseline, as well as a comparison with world benchmarks, in this case, the European Union (EU).

It is important to emphasize that the scope of this technical assistance lays the foundations of a circular economy roadmap for each country at a general level, based on the information obtained during this stage of evaluation of the current state of the circular economy in the three levels of analysis.

During the development stage of the detailed roadmap by sector and by key aspect that will be in charge of the country, the availability of information and the methodology for the construction of these baseline indicators must be validated by specialists in each subject. Within this stage, the mechanisms and instruments for monitoring the country's progress in its transition to the circular economy will be determined, instruments that must comply with a transparency and data generation approach for strategic decision-making.

At the meso and micro level, a preliminary matrix of indicators is also proposed, which will be determined as a baseline since sufficient information is available, according to the diagnostic stage of this project. In this case, the reference framework designed for the Flanders Region, Belgium was taken as a reference, due to its similarity in sectoral and regional terms and its integration with the European Union.

The comparative analysis of these indicators allowed us to glimpse some opportunities for improvement for each of the countries. It also made it possible to identify the need to include an open data system where the progress of circular design decisions for products or services, the impacts on the implementation of clean technologies in the industry and the implementation of instruments are reported time by time. regulatory, financial and fiscal oriented towards sustainable production, responsible consumption and the deployment of research and innovation projects in the field of sustainability.

Also, a series of indicators were proposed that may reflect in greater depth key aspects of the Circular Economy, but for which it is necessary to establish mechanisms and protocols to collect the information and to establish a transparent and traceable baseline.

It is important to consider that the proposed indicators are designed for a state of transition from a linear economy to a circular economy. It should be clarified that there will be results that directly contribute to the mitigation of socio-environmental impacts, without this meaning that the principles of the circular economy have been adopted in itself (for example, the use of energy from contaminated discarded materials contributes to mitigation of impacts but is based on a linear economic model that depends on the generation of the waste cyclically). These results will serve, during this stage, to compare practices of different countries in the region, aimed at mitigation in the first instance, and towards the creation of value, competitiveness and / or regeneration of natural resources under the principles of circular economy in the future, as they move towards gradual adoption of the circular economy.

The information presented in this report serves as an input for the development of a detailed Circular Economy roadmap where the establishment of relevant metrics is established as a priority activity according to the needs of each country and the mechanisms to calculate and report the indicators. This frame of reference and monitoring system will serve as the implementation system of said roadmap, multi-level and focused on the fundamental aspects of development of each country and the region.

It should be noted that the reference framework developed for these four countries has been structured in such a way that it will allow building the baseline by company or organization, subsequently integrating the metrics at the sectoral, city or territorial level, and integrating them on a macro scale, determining progress and impacts at the country level, so it will be the task of the countries to continue with the definition of the strategic indicators that will be part of this monitoring system, as well as to establish the calculation methodologies that provide the relevant information for decision-making, according to the agenda of mitigation and adaptation to climate change, competitiveness and business innovation and social impact. In the dashboard attached to this document, an initial proposal of indicators is presented in various aspects on which the circular economy roadmap for each country will be developed (see document: **D3.4_EC_Monitoreo_KPIs_Dashboard_FINAL**).

Complementary to this frame of reference, the countries must advance in an agile way in the construction of a regulatory and normative framework that enables the transition towards the Circular Economy, where the strategic legislation that allows it must be established, and the technical norms regulate it properly under a stimulating approach towards this transition while limiting or sanctioning the practices that are detrimental to it.

The reference framework presented has been designed and developed under the understanding that the four countries of the study, and others in the region that join in the future, can harmonize their progress and thereby promote regional decisions that accelerate the implementation process.

As part of the development agenda of the enabling mechanisms that catalyze this transition, countries must develop educational programs at the various academic levels that generate awareness of the paradigm shift, transferring the skills of the jobs that will be developed in this new economy and that they promote the development of research, technological projects and innovation for this purpose. Likewise, an economic development agenda must be designed that is based on financing models and instruments for innovation, entrepreneurship, and the development of a new business model in the Circular Economy.

A significant aspect within this frame of reference is the importance of Latin American cities due to the growth dynamics that they currently present and that in the future will represent a greater intensity in the demand for natural resources, in the emission of pollutants and in demographic concentration that increases the need for job opportunities. For this reason, the analysis of development and migration to urban centers has been included, from a perspective focused on technological implementation under the concept of "smart cities" that systematize public services, the development of sustainable infrastructure and the circularization of industries by taking advantage of competitive opportunities, creating new markets and higher quality jobs.

Finally, it should be noted that these four countries (Brazil, Chile, Mexico and Uruguay) are among the pioneer countries that will establish the first framework where other Latin American countries will be able to harmonize their reference frameworks, compare progress and consolidate regional progress in the medium and long term. The circular economy frameworks in developing countries will play a fundamental role as measurement instruments during the implementation of circular economy roadmaps, which are just in the process of definition and preparation.

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