Quality Infrastructure for the Circular Economy in Latin America and the Caribbean

Number 1 — QUALITY INFRASTRUCTURE OF THE AMERICAS PAPERS

Authors:
Evelyn Canelas-Santiesteban, Ulrich Harmes-Liedtke, Alexis Valqui, Mahdha Flores-Campos, Gabriel Lugo, Walter Liewald, Mauro Rivadeneira

QICA Quality Infrastructure Council of the Americas
COPANT
IAAC Inter-American Accreditation Cooperation
SIM Sistema Interamericano de Metrología
OAS More rights for more people
PTB Physikalisch-Technische Bundesanstalt Nationales Metrologieinstitut
german cooperation DEUTSCHE ZUSAMMENARBEIT

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Acknowledgments

This publication is the result of financial support from the German Federal Ministry for Economic Cooperation and Development (BMZ) through the Physikalisch-Technische Bundesanstalt (PTB), within the framework of the Quality Infrastructure for Circular Economy in Latin America and the Caribbean (QI4CE LAC) Project and under the overall guidance of Thomas Bollwein, Project Coordinator, Section 9.33 Latin America and the Caribbean of PTB.

The Quality Infrastructure Council of the Americas (QICA) acknowledges the contributions made in the revision of this publication by the Pan American Standards Commission (COPANT), the Inter-American Metrology System (SIM), the Inter-American Accreditation Cooperation (IAAC) and project stakeholders.

This study was prepared by Evelyn Canelas-Santiesteban, Ulrich Harmes-Liedtke, Alexis Valqui, Mahdha Flores-Campos, Gabriel Lugo, Walter Liewald and Mauro Rivadeneira, international experts on the quality infrastructure and the circular economy from the Physikalisch-Technische Bundesanstalt (PTB).

Quality infrastructure for the economy circular in Latin America and the Caribbean
Serie: Quality Infrastructure of the Americas Papers
Number: 1

Series editor: **Physikalisch Technische Bundesanstalt (PTB)**
Bundesallee 100, D-38116 Braunschweig, Germany

First Edition
Braunschweig, Alemania, PTB, October 2022

ISSN: 2752-1540 (online version)
Printed in Quito, Ecuador.

This publication should be cited as: Canelas-Santiesteban, E., Harmes-Liedtke, U., Valqui, A., Flores-Campos, M., Lugo, G., Liewald, W., Rivadeneira, M. 2022. "Quality infrastructure for the economy circular in Latin America and the Caribbean", Quality Infrastructure of the Americas Papers, Number 1, First Edition, Quality Infrastructure Council of the Americas (QICA), Quito, Ecuador.

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Acronyms and abbreviations

AB	Accreditation Body
ABNT	Brazilian Association of Technical Standards
APAC	Asia Pacific Accreditation Cooperation
BIPM	International Bureau of Weights and Measures
CAB	Conformity Assessment Bodies
CABUREK	Capacity Building in Technical and Scientific Organizations Using Regional Experience and Knowledge
CE	Circular Economy
CENAM	Mexican National Metrology Centre
COPANT	Pan American Standards Commission
CTCN	Climate Technology Centre and Network
EA	European co-operation for Accreditation
ECLAC	Economic Commission for Latin America and the Caribbean
GHG	Greenhouse Gases
IAAC	Inter-American Accreditation Cooperation
ICONTEC	Instituto Colombiano de Normas Técnicas y Certificación
IDB	Inter-American Development Bank
IEC	International Electrotechnical Commission
INDOCAL	Dominican Institute for Quality
INMETRO	azilian National Institute of Metrology, Quality and Technology
ISO	International Organization for Standardization
KAS	Konrad Adenauer Foundation

MoU	Memorandum of Understanding
MSMEs	Micro, Small and Medium Enterprises
NMI	National Metrology Institute
NQP	National Quality Policy
NSB	National Standards Body
OAS	Organisation of American States
ODAC	Organismo Dominicano de Acreditación
SDG	Sustainable Development Goals
OCDE	Organización para la Cooperación y el Desarrollo Económico
OIML	International Organisation of Legal Metrology
ONAC	National Accreditation Body of Colombia
PACE	Platform for Accelerating the Circular Economy
PTB	Physikalisch-Technische Bundesanstalt
QI	Quality Infrastructure
QI4CE LAC	Quality Infrastructure for Circular Economy in Latin American and the Caribbean
QICA	Quality Infrastructure Council of the Americas
SIM	Inter-American Metrology System
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organisation
VIM	International Vocabulary of Metrology
WEF	World Economic Forum

Executive summary

This study is the result of the sum of experiences and research on the interrelation between quality infrastructure and circular economy, from its fundamental concepts to its application. The processes, products and/or services of any organization need to ensure the confidence of users and consumers. The elements that make up the quality infrastructure such as metrology, standardization, accreditation and conformity assessment are essential to contribute to this end.

Chapter 2 describes the circular economy in its broad field of application, taking into account the particularities of the region. It starts with an analysis of the concept and its evolution, and takes as a reference the definition developed by the International Organization for Standardization (ISO) in its 59000 series. This defines it as an "economic system that uses a systemic approach to maintain a circular flow of resources by regenerating, retaining or adding to their value, while contributing to sustainable development". From this systemic viewpoint, the macro, meso and micro levels are highlighted for the measurement and evaluation of circularity.

The survey of different currents of thought and proposed postulates from Europe and North America, as well as works from the region, reveal the need to adapt and implement the circular economy to the cultures and economies of the region, so that its understanding and application translate into prosperity, well-being, inclusion and capacity for ecosystem regeneration. There are still challenges of learning and implementing the circular economy that must be addressed according to the region's own cultures and economies.

Chapter 3 describes the elements and activities that make up the quality infrastructure system composed of standardization, metrology, accreditation and conformity assessment. Quality infrastructure, as its definition indicates, is a fundamental element to promote and sustain economic development, as well as environmental and social well-being, while contributing with scientific-technical-operational elements that reliably support the application of the principles of the circular economy.

Chapter 4 identifies the needs of the circular economy to which quality infrastructure can contribute specifically through standardization, metrology, accreditation and conformity assessment. Finally, the **Annexes** section presents case studies on the value chain of waste electrical and electronic equipment in Ecuador, quality assurance in measurements to determine the biodegradability of chemical substances in Costa Rica and the validation of polymer products (single-use plastic bags) claimed to be biodegradable in Mexico, which demonstrate the contribution of quality infrastructure to the circular economy.

In conclusion, the existence of quality infrastructure systems in the economies of the region, and their interaction with users and promoters of the circular economy, is essential for the functioning, efficient and reliable operation of policies that support an integrating vision in Latin America and the Caribbean.

1

Introduction

This study represents a first diagnosis of the potential contributions of quality infrastructures to the circular economy. It has been prepared within the framework of the regional project Quality Infrastructure for Circular Economy in Latin American and the Caribbean (QI4CE LAC) and in application of the CABUREK methodology (Capacity Building in Technical and Scientific Organizations Using Regional Experience and Knowledge). Its objective is to strengthen the relationship between the quality infrastructure and its users, such as industry, commerce and society in general.

THE QI4CE LAC PROJECT IS BASED ON A COORDINATED EFFORT BETWEEN THE REGIONAL ORGANIZATIONS RELATED TO QUALITY INFRASTRUCTURE, WHICH MAKE UP THE QUALITY INFRASTRUCTURE COUNCIL OF THE AMERICAS (QICA).

The QI4CE LAC project is based on a coordinated effort between the regional organizations related to quality infrastructure, which make up the Quality Infrastructure Council of the Americas (QICA), i.e. the Pan American Standards Commission (COPANT), the Inter-American Accreditation Cooperation (IAAC) and the Inter-American Metrology System (SIM). It is financed by the German Development Cooperation and executed by the Physikalisch-Technische Bundesanstalt (PTB), its political partner being the Organization of American States (OAS).

This research paper aims to clarify the role of quality infrastructure in the transition of Latin American and Caribbean countries towards a circular economy by promoting communication and interaction among all stakeholders -business, government, academia and civil society- and, in turn, to strengthen cooperative relationships through the proposed guidelines. It is based on data and information available for the most part up to the first half of 2022.

The study is organized in three parts. Part One presents the origins, the development of the circular economy concept and the shared vision in Latin America and the Caribbean. At the same time, the authors highlight the particularities of the development and implementation of the circular economy in the region.

Part Two focuses on the regional experience and introduces the terms referring to quality infrastructure, its components, cooperative relationships at different scales and the current situation.

In relation to the information and data presented in the previous chapters, the third part addresses the contribution of quality infrastructure to the circular economy in the region by identifying the main needs of the circular economy in which quality infrastructure, through standardization, metrology and accreditation, can provide specific and significant support.

Finally, the Annexes section exemplifies the interrelationship between the quality infrastructure and the circular economy, both of which are recognized as dynamic systems.

The application of the action-research approach favored the approach with the actors involved during the stages of the study process, who enriched the data on how the quality infrastructure lays the foundations for circular transformation in a harmonious, comparable and traceable framework.

It is hoped that this work will also stimulate debate and proposals on the role of current and future quality infrastructure services, both current and future, in contribution to the needs and challenges presented by the circular economy towards new opportunities for local economic development, creation of social value and improvement of the quality of life.

2

Circular economy: concept and application in Latin America and the Caribbean

What is the circular economy?

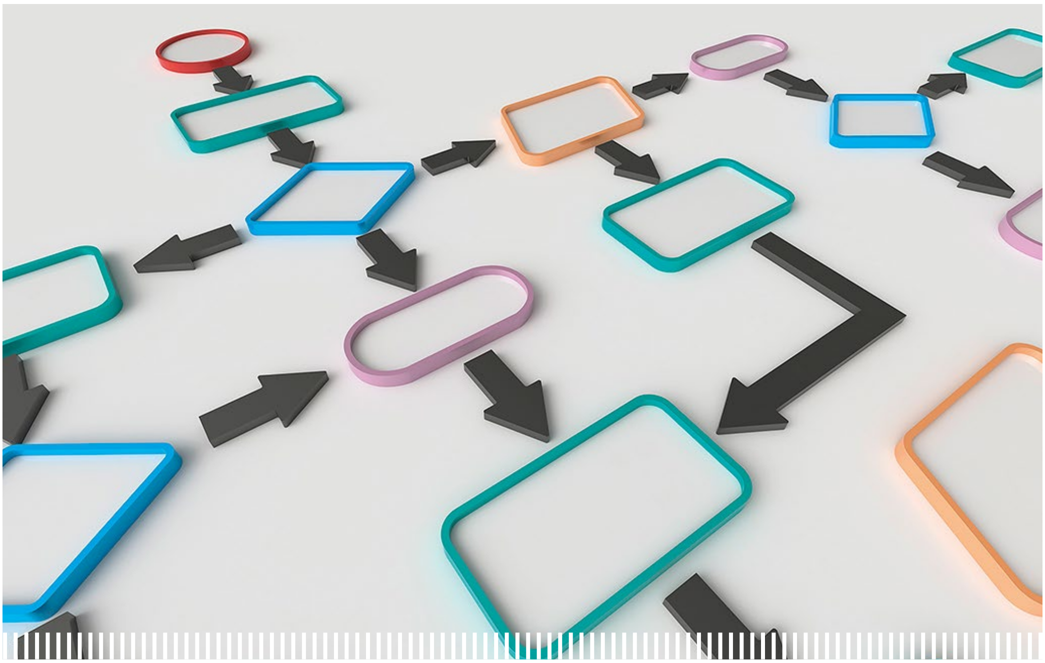
The circular economy contrasts with the dominant paradigm of the linear production-consumption-disposal economy that has strong environmental consequences with clear manifestations such as global warming, ecosystem imbalance, biodiversity loss, water scarcity, among others, reflecting the urgent need for change in our economies.

The Ellen MacArthur Foundation, one of the organizations promoting the concept of circular economy, proposes the following definition:

> *"A circular economy is a restorative or regenerative industrial system by intention and design. It replaces the concept of 'expiration' with that of 'restoration',*

1 C. de Miguel, K. Martínez, M. Pereira and M. Kohout, "Economía circular en América Latina y el Caribe: oportunidad para una recuperación transformadora", Project Documents (LC/TS.2021/120), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2021.

SOURCE: INFOGRAF/ISTOCKPHOTO



shifts to the use of renewable energy by eliminating the use of toxic chemicals that impair reuse, and the return to the biosphere and seeks instead to eliminate waste through optimized design of materials, products and systems and, within these, business models".[2]

On the path towards the harmonization of frameworks, terminology, business model design and tools for measuring and evaluating circularity, the International Committee TC/323 Circular Economy of ISO (International Organization for Standardization) is officially formed in June 2019, driven by AFNOR (French Association for Standardization) and implemented through Working Groups and the participation of technical experts from more than 65 countries with a significant representation of developing countries.

Through the presentation of national positions, technical proposals, facilitation of drafting groups, exchange sessions, among other activities, shared visions and strategies for action have been expressed in consideration of the diversity of realities in which the ISO community operates. One of the first points of analysis after the formation of the ISO/TC 323 Committee was to analyze the terminology and it is through ISO 59004 that the circular economy is defined as follows:

> *"Economic system that uses a systemic approach to maintain a circular flow of resources, by recovering, retaining or adding to their value, while contributing to sustainable development".*[3]

Based on this conception of the circular economy as an economic system and in correlation with the origins of this term detailed above, Figure 1 shows a representation of the boundaries of the system and its dynamic environment capable of regenerating, retaining or adding value at the level of a product (as well as the elements or materials that compose it) and of an organization (micro level), inter-organizational (meso level) and regional (macro level).

The circular economy is a means by which to contribute to the goals of sustainable development, which encompass economic growth, social inclusion and environmental protection. Consequently, it supports the fulfillment of the Sustainable Development Goals (SDGs) of the 2030 Agenda.

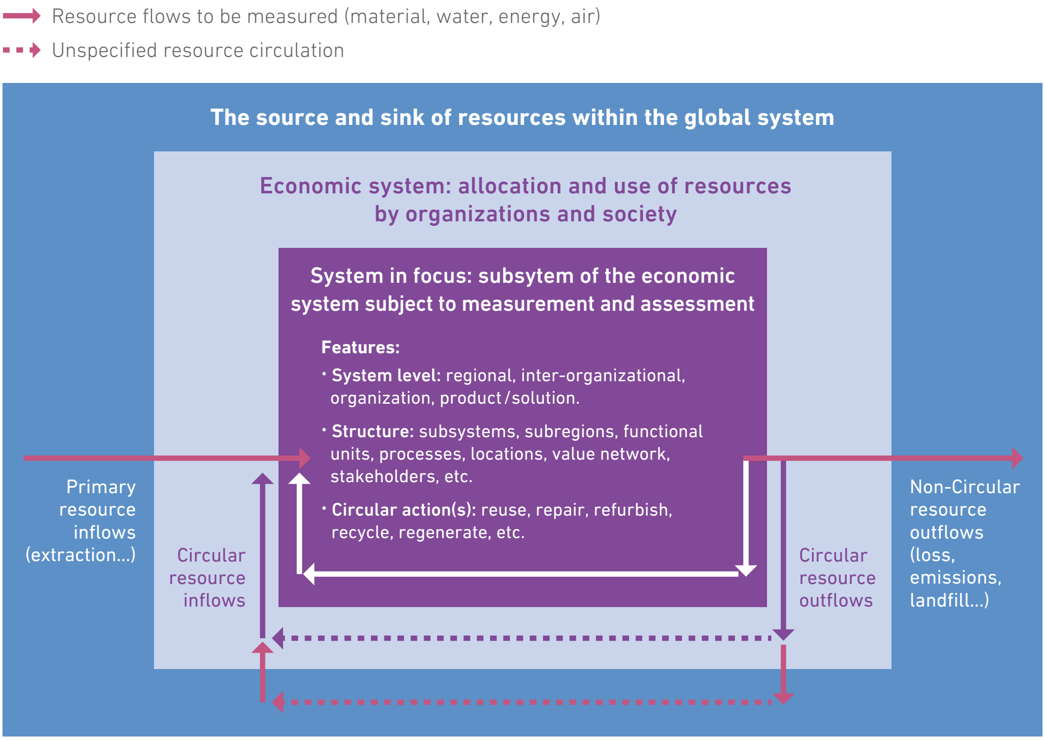
It is also important to clarify for the organizations[4] the relationships between the

2 EMF (Ellen MacArthur Foundation). 2014. Towards a circular economy. Executive Summary, United Kingdom.

3 ISO 59004.

4 ISO 59004 defines an organization as a person or group of persons having its own functions with responsibilities, authorities and relationships to achieve its objectives, e.g. sole trader, company, corporation, firm, authority, partnership, society, foundation, union, association, agency, and may be incorporated or unincorporated and may be public or private.

Figure 1. **Representation of system boundaries, relationships and implementation levels**



Source: ISO 59020 (under development).

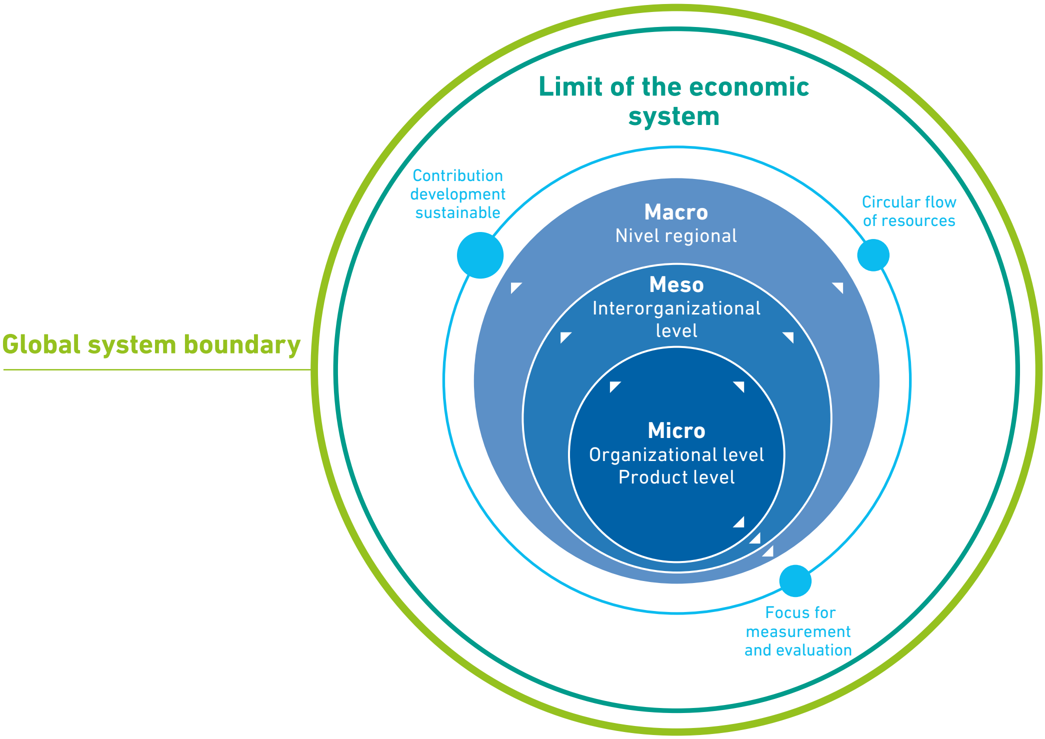
different systems represented in Figure 1, mentioning that[5]:

- The global system includes the source and sink of all resources.
- The boundaries of the economic system define the exchange of resources with the global system that are of interest to the organization and its stakeholders by performing measurement and evaluation.
- The system in focus is, in most cases, a subsystem or a combination of subsystems of the economic system, for example: business model networks of cooperative enterprises, symbiotic networks, the activities of an entire organization or the macroeconomic system of a country.

The following are the levels of implementation of the circular economy based on the guidelines established in the ISO 59000 series of standards (Figure 2).

According to the levels of implementation of the circular economy (Figure 2),

Figure 2. Levels of implementation of the circular economy based on the ISO standards approach



Source: Own elaboration, 2022.

we have initially identified the micro level, which corresponds to the evaluation of the circularity of a given product (goods or services), as well as the components and materials that are part of it and the evaluation of circularity focused on an individual organization; the meso level applied to the evaluation of circularity for a set of organizations; and the macro level for the evaluation of circularity at the level of geographical areas -countries, cities, municipalities, provinces, states, regions, among others-.

Among the tools considered for circularity assessment, ISO 59010 recognizes the LCA (Life Cycle Assessment) as a useful tool that can be used by organizations in the transition to circularity and also opens up the possibility of using other tools or methodologies that are more accessible to the organization.

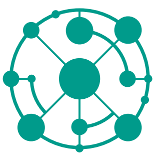
5 ISO 59020.

6 LCA is defined by ISO 59004 (under development) as the compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system throughout its life cycle.

Other definitions that stand out from ISO 59004 are, for example, value chain, as “a set of organizations that together in an organized way provide a solution that results in value for them”[7], and value network, as “a network of interrelated value chains and stakeholders”.[8]

Another draft standard that has resulted in a Joint Working Group between ISO/TC 207 SC5 and ISO/TC323 JWG14 is also mentioned: ISO WD 59014 - Secondary materials: principles, sustainability and traceability requirements. It defines secondary materials as follows: “Material that has been used and subsequently processed”. It provides a framework and guidance for activities and processes related to the generation of secondary materials. It establishes measures to enable traceability of secondary materials and unrecovered waste in an organization’s value chain, and addresses activities and processes within the formal and informal sectors to facilitate the transition from informal to formal operations.

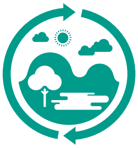
ISO 59004 establishes six principles on which the framework for implementing the circular economy in organizations is based:



1. Systems thinking. Organizations apply a long-term systems perspective considering the impacts of interactions between environmental, social and economic systems, taking into account the life cycle perspective of their solutions.

2. Value creation. By regenerating, retaining or adding value, organizations provide effective solutions by using resources efficiently and contributing to meeting society’s needs. They minimize the extraction of non-renewable resources and manage renewable resources to regenerate and enhance value over time.

3. Shared value. Organizations and stakeholders collaborate along the value chain or value network in an inclusive and equitable manner, for the benefit and welfare of society, sharing the value created by providing a solution.



4. Resource availability approach. Organizations manage and regenerate stocks and flows of resources in a sustainable manner to contribute to their availability for present and future generations and continue to regenerate, retain or add value, while ensuring the quality and resilience of ecosystems.

5. Resource traceability. Organizations manage and track stocks and resource flows in a transparent and accountable manner so that they continue to regenerate, retain or add value, while maintaining the circular flow of resources.

6. Ecosystem resilience. Organizations develop and implement [circular] practices and strategies that protect and contribute to the regeneration of ecosystems and their biodiversity, taking into account planetary boundaries.

In summary, the circular economy as a dynamic economic system is capable of contributing to the three dimensions of sustainable development when adding, retaining or regenerating value at their respective levels of implementation (micro, meso and macro). The draft Standards of the ISO 59000 series (ISO 59004, ISO 59010, ISO 59020, ISO 59040 and ISO 59014) provide conceptual and practical guidelines for implementation in organizations, regardless of their size, sector or geographical location.

It is hoped that each country will be able to appropriate these standards for their subsequent application, whether in adoption and adaptation, or in the promotion of new local and international cooperation projects, business initiatives, planning instruments, national roadmaps, laws, regulations, among others.

7 ISO 59004 (under development).
8 Idem.

Origins and development of the circular economy concept

The concept of circular economy arises from various currents and positions from the global north and south. Among them, the work of the British Kenneth Boulding (1956), author of "General Systems Theory: The skeleton of science".

He contemplates that any phenomenon is part of a system and that, at least potentially, it can also be a system in itself.

In this sense, it proposes a classification of nine levels of systems, ordered from the lowest to the highest degree of complexity. It was on the basis of this theory that the development of systemic thinking, which today represents a significant contribution to scientific knowledge, was built.

SOURCE: SAE, 2022.

This position was taken up years later in the book "Economics of Natural Resources and the Environment" by Pearce and Turner (1990), published by Johns Hopkins University. They are credited with introducing for the first time the idea of circular economy to represent an economic system where elements of sustainability are also analyzed. For his part, Walter Stahel (1978), in his article entitled "The Product Life Factor", supports the importance of applying life extension strategies and reconditioning to the supply of services instead of the po- ssession of goods, or what is now known as "product as a service" (PaaS). This is supported in everyday practices such as: renting vehicles instead of selling them, reusing clothing or repairing household items.

Between 1972 and 1975, the Latin American World Model was born, promoted by the Bariloche Foundation of Argentina, as an alternative response to the study "The Limits to Growth" (1972) carried out by the Massachusetts Institute of Technology (MIT) and supported by the Club of Rome. This model, with Latin American roots but global application, postulates that only radical changes in the social and international organization of today's world can liberate people from backwardness and oppression.

It is based on equality and the full participation of all human beings in social decisions, defining food, housing, education and health as basic needs. The circular economy is based on collaboration, the fight against inequalities and inclusion. Therefore, this model has been analyzed when developing future works that focus on social impact without neglecting the environmental and economic dimensions of sustainable development.

Similarly, schools of thought were established, such as the *cradle-to-cradle* design approach of William McDonough and Michael Braungart; the idea of biomimetics presented by Janine Benyus; the industrial ecology of Reid Lifset and Thomas Graedel; the natural capitalism of Amory and Hunter Lovins and Paul Hawkens; the performance economics of Walter Stahel; and the blue economy approach, as described by Gunter Pauli.[9]

The circular economy opens the way to a broader debate linked to the concept of decoupling, which represents the ability of an economy to grow without corresponding increases in environmental pressure.[10] This is because, by avoiding the input of new material and energy into processes, it reduces environmental pressure in the life cycle of products (EEA, 2017).

9 Ellen MacArthur Foundation, 2021.

10 Harmes-Liedtke, U., Stamm, A. 2021. Green Economy, Innovation and Quality Infrastructure: A baseline study about the relevance of quality infrastructure for innovations in the green economy in Latin America and the Caribbean. Braunschweig: PTB.

However, this decoupling can be relative or absolute. Jackson (2009) highlights the importance of differentiating between the two terms, denoting that relative decoupling is one that refers to a decrease in resource and emissions intensity per unit of economic output. Resource impacts fall relative to gross domestic product, which may still be increasing. Absolute decoupling, on the other hand, corresponds to a situation in which resource impacts decrease in absolute.

Against optimistic positions that use the term decoupling as an escape route from the growth dilemma, Jackson (2009) argues that there is sufficient evidence to support the presence of relative decoupling in global economies and that evidence of absolute decoupling is harder to find.

Now, Blomsma and Brennan (2017) state the importance of conceiving the circular economy as a framework concept or umbrella[11] from the notion of Hirsch and Levin (1999) to understand its role in the current debate on waste and resource management. The same by the International Reference Center for the Life Cycle of Products, Processes and Services (CIRAIG, 2015), which assumes the circular economy as a conceptual umbrella.

With the purpose of supporting these considerations, the periods of conceptual development of the circular economy are presented:[12]

Preamble period: 1960-1985. This first period paid special attention to both industrial and municipal end-of-life processes and their impact on the environment. The publication of the book "Silent Spring" stands out and, with it, the formation of the first environmental movements, as well as currents of thought based on the impacts produced by the contamination of water bodies, the indiscriminate use of pesticides and the demand for corrective measures to be taken by the industrial system. Likewise, the publication of the report "The Limits to Growth" (Meadows, et al., 1972), derived from the Club of Rome in the United States and prepared by the Massachusetts Institute of Technology (MIT) in the period prior to the oil crisis, sharpened environmental awareness through the emergence of new platforms, collectives and organizations that sought to promote respect for and protection of natural resources.

11 Umbrella concepts consist of creating a relationship between pre-existing concepts that were previously unrelated, or unrelated in the way that concept proposes, by focusing attention on a particular quality or characteristic according to (Blomsma, F., Brennan, G., 2017).

12 Blomsma, F., Brennan, G. 2017. The Emergence of Circular Economy: A New Framing Around Prolonging Resource Productivity. Journal of Industrial Ecology, UK.

13 Carson, R. 1962. Silent Spring. Boston. Houghton Mifflin Company.

14 The report "Our Common Future" (1987) defines sustainable development as development that meets present needs without compromising the ability to meet the needs of future generations.

Circular economy schools of thought

1990 **Blue economy**

The concept was established by the economist Gunter Pauli, author of the 1994 book "The Blue Economy". This school of thought focuses on the recovery of ecosystems, accessibility and the need to raise awareness of the importance of the ocean and coastal resources beyond fishing and tourism.

1980 **Industrial ecology**

Introduced by Robert Frosh and Nicholas Gallopoulos, it consists of emulating an ecosystem by developing associative industrial activity. This implies that no company should operate independently. On the contrary, chains of mutual collaboration should be generated to achieve a significant reduction in the impact caused by each one of them.

1980 **Cradle to cradle**

B. McDonough and M. Braungart reformulated the cradle to cradle theory and took the idea of completely changing the model of consumerism (design, create, dispose of) or linear economy to eliminate waste, give value to it and use renewable energy sources, mainly the sun.

1976 **Performance economy**

Walter Stahel showed the importance of a spiral (or circular) economy and its impact on job creation, economic competitiveness, resource savings and waste prevention. He was the first to coin the Cradle-to-Cradle (C2C, also known as cradle-to-cradle) concept in the late 1970s.

1970 **Regenerative design**

John T. Lyle proposed ideas related to the principles of highly sustainable living based on education, research, demonstration and community outreach.

Period of emotion: 1985-2013. Waste is assumed as a source of value and thinking focused on pollution and its impacts is losing strength. A widely recognized event during this period was the debate on sustainable development, an important catalyst being the report "Our Common Future" or also known as the Brundtland Report, published by the United Nations World Commission on Environment and Development (1987) in which sustainable development was recognized as an opportunity.

Period of validity challenge: 2013 to date. Spaces for discussion and critical thinking are facilitated to face the challenge of validity of the concept and, with this, generate the necessary tools that allow its application and measurement. This is the last period of development of the concept, when the interpretations and diversity of approaches are most intensely manifested, which implies that the theoretical or paradigmatic clarity on the concept of circular economy has not yet emerged. An example of this is to distinguish between recycling, down-cycling and cascading, there are no well-established means to differentiate between these strategies quantitatively or conceptually. However, circular metrics are already being proposed (EMF 2015 and Granta 2015; Linder et al. 2017), leading different assessments to be incomparable.[15]

Figure 3 illustrates a timeline corresponding to the periods of development of the circular economy concept, as well as the periods ahead. The transition between each period is represented as a gradient because no single event can be identified as causing the transition and because the exact times differ in each region.[16]

Particularly in Latin American and Caribbean countries, public policies, roadmaps, economic incentives, projects, regulations, among other instruments developed, are focused on recycling. Although it represents a strategy within the circular economy, it is not everything, so the actors involved in the system - governments, public policy makers, companies, entrepreneurs, startups, foundations, academia, chambers of industry and commerce, quality infrastructure organizations, international cooperation, financial system, among others - need to articulate and strengthen existing efforts towards the life cycle perspective and the systemic approach.

In order to guide the development of the concept and application of the circular economy from a systems perspective, it is necessary to analyze the contribution that industrial ecology and its integration with other disciplines such as law, ethics, economics and sociology can offer. (Hoffman, 2003) argues the importance of having a broader spectrum of analysis.

Studying the behavior of life extension strategies and circularity strategies in general supports this purpose when evaluating cases where two or more different strategies work together in sequence or in parallel. For example, how recycling and reuse could generate synergies.[17] This will also represent an input in the process of harmonizing circular economy frameworks.

And in relation to this development described above, like any other system, it will constantly evolve, seeking that the current and future currents of thought are transferred to action and that we see them applied in our daily activities, design, production and community life.

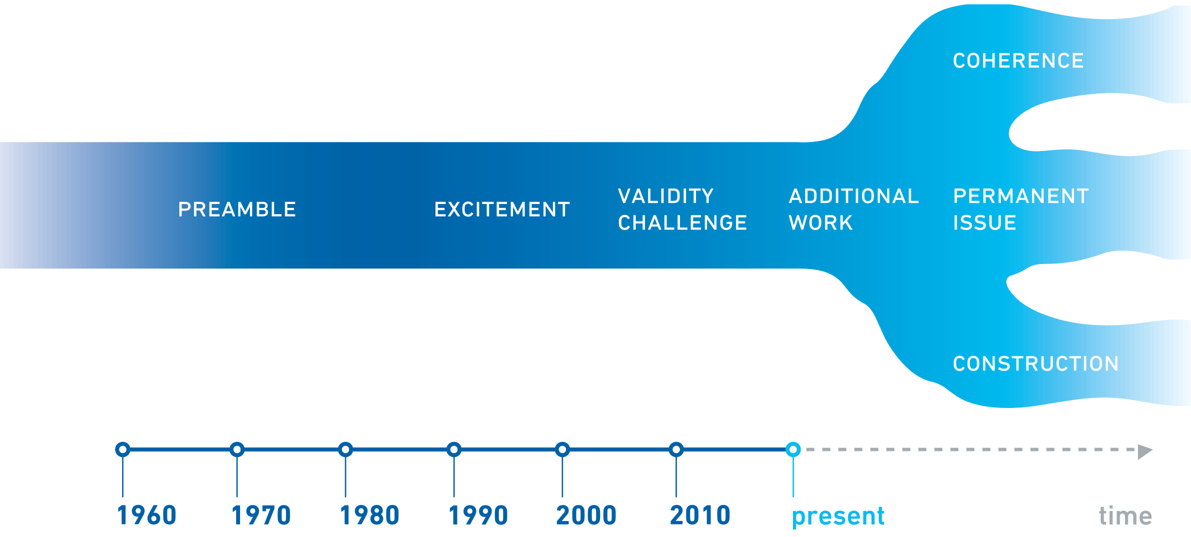
In the book "Designing Regenerative Cultures", (Wahl, 2021) he raises the need to reflect while we ask ourselves about the what, the how, the when and the where;

15 Blomsma, F., Brennan, G. 2017. "The Emergence of Circular Economy: A New Framing Around Prolonging Resource Productivity". Journal of Industrial Ecology, UK.

16 Idem.

17 Idem.

Figure 3. **Periods of development of the circular economy concept**



Scope of frame
Production & end-of-life.

Purpose
Reduce landfilling + improve well-being of humans and environment.

RLESs in service of purpose
Product cascades, waste-to-energy, recycling, composting.

Scope of frame
Complete life-cycle.

Purpose
Reduce wastefulness & source of raw materials + create environmental, social and economic win-wins.

RLESs in service of purpose
Product-service systems (with associated repair, refurbishment, upgrading, remanufacturing and product longevity), reuse, recycling, urban mining.

Note. This figure shows the periods of development of the circular economy concept. Adapted from "The Emergence of Circular Economy: A New Framing Around Prolonging Resource Productivity" (p. 607), by Blomsma, F. and Brennan, G., 2017, Journal of Industrial Ecology, UK.

about this individual and collective transformation so necessary to co-create a prosperous future and learn to transcend and integrate our differences from critical thinking.

Finally, we emphasize the importance of collaboration among system actors for the journey towards regenerative and inclusive economies to enable this transformation.

Regional context of the circular economy

In recent years, the development of regulations and planning instruments on circular economy in countries such as Colombia[18], Chile[19], Ecuador[20], Mexico[21], Costa Rica[22], Peru[23] and Dominican Republic[24], the development of projects from the business sector that support local production, the creation of clusters, programs to support the entrepreneurship ecosystem and research initiatives, have given rise to greater attention to this issue that quickly leads to transformation processes in the agendas of cities and regions.

Despite these important initiatives, there is still a trend in the region associated

18 In 2018, Colombia presented the National Circular Economy Strategy. This was promoted by the Ministry of Environment and Sustainable Development and had the participation of productive sectors, academics, citizens, entrepreneurs and civil society organizations. This strategy is currently being implemented through the operation of Working Groups organized by theme, which facilitate communication, articulation of actions and monitoring of progress.

19 In 2021, Chile developed a Roadmap for a Circular Chile by 2040 with the participation of a Strategic Committee made up of representatives from the public and private sectors, civil society and academia, as well as an International Advisory Committee that actively accompanied the process. The vision of this instrument is that by 2040, the regenerative circular economy will drive Chile towards a sustainable, fair and participatory development where the focus is on the welfare of people.

20 In Ecuador, the Circular Economy Pact was signed in 2019. From this basic instrument, the preparation of the White Paper on Circular Economy was promoted. On July 6, 2021, the Organic Law of Inclusive Circular Economy was enacted and its general regulations are currently in the process of approval.

21 At the local level, the Government of Mexico City presented the Mexico City Action Plan for a Circular Economy. And in 2021, the General Law of Circular Economy was enacted.

22 In 2020, Costa Rica approved the National Bioeconomy Strategy, which proposes an economy based on knowledge, competitiveness, the application of the principles of a circular bioeconomy and the decarbonization of production and consumption processes. The National Circular Economy Strategy is now in the process of being drafted.

23 In 2020, Peru approved the roadmap towards a circular economy in the industrial sector. It was driven by the Ministry of Production and the Ministry of Environment in coordination with the industrial sector and stakeholders.

24 In 2020, the Dominican Republic enacted the General Law on Integrated Management and Co-processing of Solid Waste.

25 N. Mulder and M. Albaladejo. 2020. International Trade and the Circular Economy in Latin America and the Caribbean. International Trade Series, No. 159 (LC/TS.2020/174), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

with traditional waste management. This can be reinforced from a life cycle perspective and address the development of all sectors involved in the circular economy (construction, finance, textiles, energy, built environment, etc.).

Circularity also saves costs, promotes the development of new business models and helps to preserve raw materials that are finite resources. This reduces supply disruptions and thus ensures their long-term use by economies.[25]

Examples of circular economy instruments developed in Latin America and the Caribbean

- Legislation (laws, regulations or others).
- Tools and instruments planning (strategies national leaves route plans or programs).

Dominican Republic
- General Law of Comprehensive Management and Solid Waste Co-processing (2020)

Mexico
- Mexico City Action Plan for a circular economy (2019)
- General Law of Circular Economy (2021)

Costa Rica
- National Bioeconomy Strategy (2020)
- National Economy Strategy Circular (developing)

Ecuador
- Pact for the Circular Economy (2019)
- Circular Economy White Paper (2021)
- Organic Law of Circular Economy inclusive (2021)
- National Circular Economy Strategy (developing)

Colombia
- National Circular Economy Strategy (2018)

Peru
- Roadmap towards a Circular Economy in the Industry Sector (2020)

Chile
- Roadmap for a Circular Chile by 2040

Source: own elaboration, 2022.

4.8

million jobs would be created by the circular economy in Latin America and the Caribbean by 2030.

Source: International Labor Organization (ILO, 2018).

In economic terms, it is estimated that the different transformation strategies to the circular economy can generate net benefits such as GDP increases of between 0.8% and 7%, job growth of between 0.2% and 3% and carbon emission reductions of between 70% and 85%.[26]

The circular economy has the potential to drive reindustrialization by promoting sectors such as the valorization of secondary raw materials, repair, reconditioning and remanufacturing, services and the solidarity economy. It brings value to local economies by supporting the development of new skills, generating new jobs and promoting exchanges between companies and the building of synergies[27].

Although micro, small and medium-sized enterprises (MSMEs) represent the majority of the industrial fabric and create most jobs, their productivity is extremely low compared to that of large organizations. To address this situation, the region must develop productive chains composed of different sizes of companies. The purpose should be to boost job creation and wages as a way of reducing the heterogeneity of their economies.

Promoting the internationalization of these companies, particularly in their export activities, contributes to improving the productivity and labor conditions of their workers (ECLAC, 2022).

Specifically for Latin America and the Caribbean, the International Labor Organization (ILO) projects that, together with the energy transition in the region, which is expected to generate more than one million jobs by 2030, the circular economy would create a net total of 4.8 million jobs in the region by 2030.[28]

26 EllenMacArthur Foundation. 2015. Delivering the Circular Economy: A Toolkit for Policymakers.

27 N. Mulder and M. Albaladejo. 2020. International Trade and the Circular Economy in Latin America and the Caribbean. International Trade Series, No. 159 (LC/TS.2020/174), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

28 ILO. 2018. Laboursituation in Latin America and the Caribbean). Available at: https://repositorio.cepal.org/bitstream/handle/11362/44186/1/S1800885en.pdf

2.4

Vision of the circular economy: opportunities and challenges

Following the conceptual development of the circular economy parallel to the frameworks for action in the territories, different currents of thought have been identified in the Latin American and Caribbean scenarios. For example, Ecuador, Peru and Bolivia have appropriated from the regulatory framework the ideology and vision of "good living" *sumak kawsay* or "living well" *sumaq qamaña*.

In it, Mother Earth (Pachamama) is recognized as a collective subject from a pluralistic approach that seeks to promote balance between societies and between human beings and nature, without conceiving any of the parties as subordinate to the other.

SOURCE: MIKE KIEV/ISTOCKPHOTO

However, it is necessary to go beyond the rhetoric established in the regulations or ideological considerations in order for these indigenous peoples and communities in the region to acquire genuine representation in the political, economic and social spheres. This would allow them to claim their rights and join forces with the actors of the system for the co-construction of State agendas -for example, the climate agenda- that would allow the development of collective solutions.

In line with these challenges, the Circular Economy Coalition in Latin America and the Caribbean was officially established on February 1, 2021. It is coordinated by the United Nations Environment Programme (UNEP) and led by a Steering Committee made up of four high-level government representatives, who will exercise these functions on a rotating basis starting with Colombia, Costa Rica, Dominican Republic and Peru for the period 2021-2022[29]. The coalition also has strategic partners such as the Inter-American Development Bank, the Climate Technology Center and Net-work (CTCN), the Ellen MacArthur Foundation, the Konrad Adenauer Foundation, the Platform for Accelerating the Circular Economy (PACE), the United Nations Environment Programme, the World Economic Forum (WEF) and the United Nations Industrial Development Organization (UNIDO).

Since its creation, the Circular Economy Coalition has facilitated the creation of spaces for raising awareness, gathering updated data and defining key sectors (plastics, cities and construction; electronics, food and agriculture, industrial symbiosis and tourism).

Of particular note is the recent publication of the circular economy vision for the Latin American and Caribbean region. It aims to inspire and create a common direction for the region's stakeholders - governments, businesses, financiers, civil society, researchers and others - to follow towards sustainable development.

This shared vision denotes that the circular economy is about:[30]

- **Transformation and systemic change.** It offers a new model of economic development that works for and with climate and biodiversity, and is increasingly driven by renewable energies and materials.

29 **https://coalicioneconomiacircular.org/estructura-de-gobernanza/** (Accessed March 11, 2022).
30 Circular Economy Coalition in Latin America and the Caribbean (2022). Circular Economy in Latin America and the Caribbean: A shared vision. 2022.
31 Idem.
32 Schröder, P. (2020), "Promoting a just transition to an inclusive circular economy", London, Chatam House [online] **https://www.chathamhouse.org/2020/04/promoting-just-transition-inclusive-circular-economy**
33 Circular Economy Coalition in Latin America and the Caribbean (2022). Circular Economy in Latin America and the Caribbean: A shared vision. 2022.

- **Prosperity, well-being and long-term resilience.** They are key to SDG-aligned economic recovery and development that supports ecosystem well-being and regeneration.

- **Diversity and inclusion.** Mimics ecological systems, where all parts are crucial to the success of the whole system and are valued for their function.

- **Innovation and heritage.** It is based on new knowledge and technologies, on indigenous cosmovision and skills, and on formal and informal experiences from all corners.

In practice, the transformation of products and materials in the main productive sectors is reflected in the following actions: creating opportunities for local value chains to circulate products and materials at their highest value; strengthening the manufacturing base through circular economy-based production and design approaches; supporting the recycling system to create a market for higher value secondary material; and creating decent jobs and business innovations in the region.[31]

Regarding the creation of decent jobs established in SDG 8, and in line with the realities of Latin America and the Caribbean, Schröder (2020) argues that more specific support measures will be needed to formalize informal jobs in sectors such as recycling and waste management and thus transform them into decent jobs.[32]

For this purpose, the direct role of local governments in coordination with industry and civil society is fundamental to support waste pickers or recyclers in the stages of organization, development of new hard and soft skills, formalization and social and economic inclusion.

Therefore, durability, reusability, reparability, remanufacturability, recyclability, compostability and regeneration are key words for products and materials circulating within a circular economy in the region. From food to durable goods, from plastics to buildings and biomaterials; products and materials produced locally, imported or manufactured for export can become sources of innovation in a circular economy.[33]

While recognizing all actors involved in the circular economy, according to their assigned competencies and responsibilities, the Circular Economy Coalition in Latin America and the Caribbean (2022) assumes public policy makers as the facilitators of the transition, businesses as the implementers, citizens and civil society as the active participants, and investors and financiers as key actors for its large-scale implementation, in a new era of economic development where the Latin American and Caribbean region can lead this process.

SOURCEE: SAE, 2022.

Boosting jobs in the circular economy will require all actors involved to take into account the growth dynamics of the formal and informal economies, the latter being predominant in the Latin American context.

However, for this regional vision to be implemented in the different territories and levels of implementation of the circular economy, it is necessary to promote effective spaces for dialogue, establish multi-stakeholder collaborations for future projects that respond to the reality and needs of each country, promote the creation of green businesses[34] and encourage the articulation of value chains, paying special attention to the most disadvantaged links for the creation of social value. All of the above, taking into account the growth dynamics of the formal and informal economies, especially the latter, which is predominant in the Latin American context.

Proof of this is the partial reactivation of labor markets in Latin America and the Caribbean based, to a large extent, on informal work. Unemployment would fall from 10% to 9.3% in 2022 and to 8.8% in 2023.[35] Therefore, in the current context of COVID-19, various international organizations have issued a call to action so that the countries of the region recognize the transition to fairer and more resilient societies as a priority.

An important step towards strengthening the vision of the circular economy in the region is the Bridgetown Declaration[36] signed in 2021. Among its main agreements is the recognition of the 2030 Agenda and the Sustainable Development Goals as fundamental roadmaps to achieve sustainable development in its economic, social and environmental dimensions. It also emphasizes the importance of international and regional cooperation to mitigate countries' vulnerabilities, foster resilience and maximize opportunities for sustainable development.

34 In Latin America and the Caribbean, the just transition agenda to promote green jobs has been promoted since 2008 with the publication of the ILO global report "Green Jobs: towards decent work in a sustainable, low carbon world", in coordination with the United Nations Environment Program, the International Organization of Employers and the International Trade Union Confederation. This agenda is gaining ground thanks to the creation of networks, knowledge centers, publications and technical support in countries such as the Dominican Republic, Brazil, Chile, Uruguay and Panama.

35 ILO, 2022.

36 In February 2021, the environment ministers of Latin America and the Caribbean signed the Bridgetown Declaration, in which they committed to promote a reactivation based on social inclusion, low-carbon economies and sustainable use of resources.

3

Quality infrastructure in the Latin American and Caribbean region

What is quality infrastructure?

Quality infrastructure must be recognized as part of the country's entire infrastructure, with the same level of importance as roads and highways, schools, basic medical services, etc. Without quality infrastructure, development and competitiveness are not possible.[37]

The International Network for Quality Infrastructure (INetQI) defines quality infrastructure as follows:

> *"The system comprising the organizations (public and private) together with the policies, relevant legal and*

37 Sanetra, C., Marbán, R. (2007). Facing the global quality challenge: A national quality infrastructure, Physikalisch-Technische Bundesanstalt (PTB).

SOURCE: SAE, 2022.

regulatory framework and practices necessary to support and improve the quality, safety and environmental soundness of goods, services and processes. Quality infrastructure is necessary for the effective functioning of domestic markets, and its international recognition is essential to enable access to foreign markets. It is a fundamental element in promoting and sustaining economic development, as well as environmental and social well-being. It is based on metrology, standardization, accreditation, conformity assessment and market surveillance (in regulated areas)".[38]

QUALITY INFRASTRUCTURE MUST BE RECOGNIZED AS PART OF THE COUNTRY'S ENTIRE INFRASTRUCTURE. WITHOUT IT, DEVELOPMENT AND COMPETITIVENESS ARE NOT POSSIBLE.

Quality infrastructure contributes to policy objectives in areas including industrial development, trade competitiveness in markets, efficient use of natural and human resources, food safety, health, the environment and climate change.

It offers a complete package that addresses the needs of citizens, customers and consu- mers, businesses and other organizations offering products and services.

Three pillars of the quality infrastructure are recognized: standardization, metrology and accreditation. The following sections detail the framework for the application of these pillars and the so-called conformity assessment (also part of the quality infrastructure).[39]

A reliable quality infrastructure system depends on effective interactions among a series of initiatives, institutions, organizations, activities and people.

It usually includes a National Quality Policy and institutions to implement it, a regulatory framework, quality service providers, businesses, clients, and consumers (which

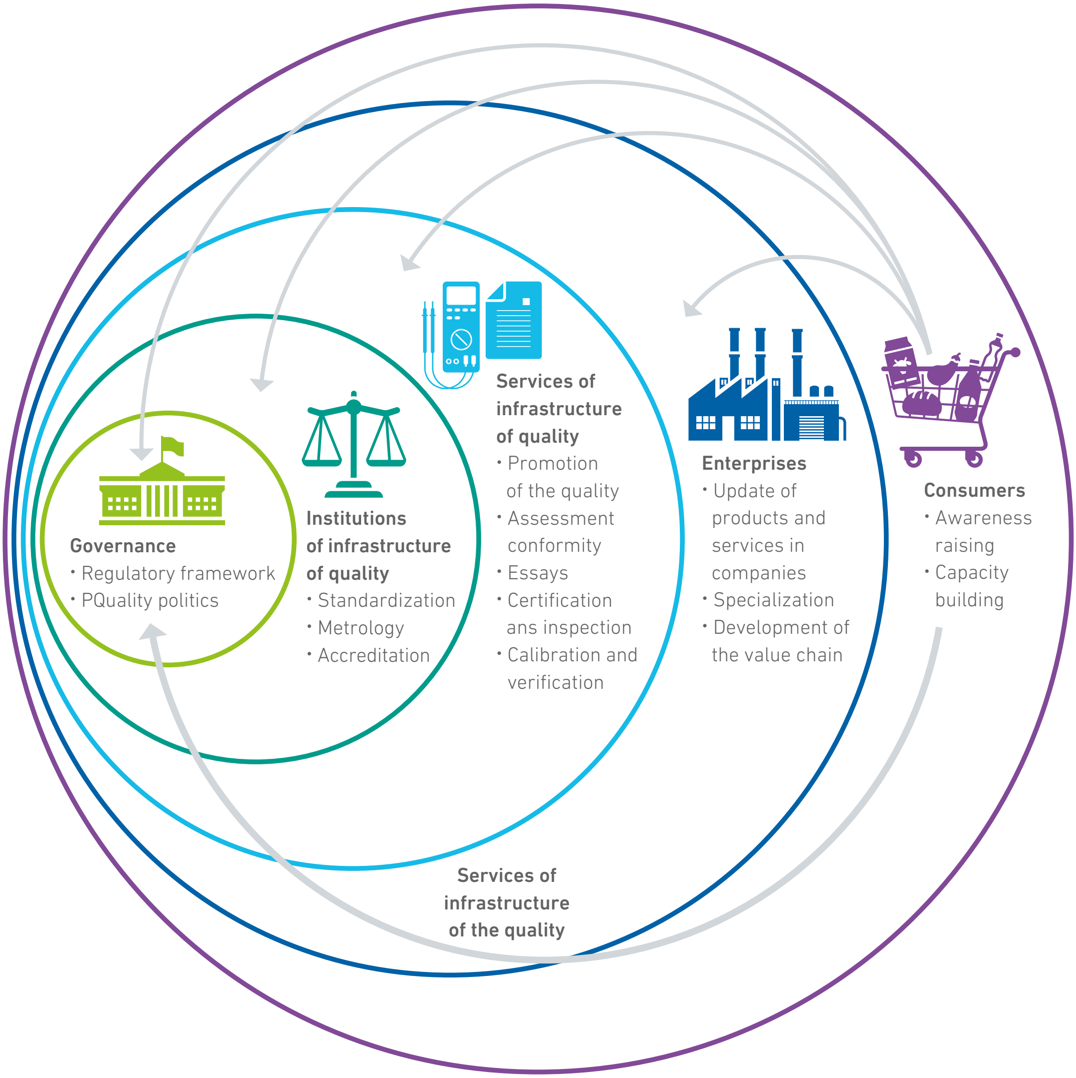
38 **https://www.inetqi.net/documentation/quality-infrastructure-definition/** (Accessed March 5, 2022 and translated by the authors).

39 For the purposes of this study, conformity assessment is included as a component of the quality infrastructure, although it is not recognized as being one of the three traditional components.

include citizens as "consumers" of government services).[40]

Figure 4 depicts the relationships in a national quality infrastructure system:

Figure 4. Representation of the interrelationship between the components of a national quality infrastructure system



Source: United Nations Industrial Development Organization, 2017.

40 United Nations Industrial Development Organization. 2017. Quality infrastructure of the Americas: strategic roadmap. Vienna, Austria.

Quality infrastructure institutions and their national competencies are usually defined by law. Some countries in the region have a Quality Infrastructure Law (Costa Rica, Mexico) and others have a National Quality Policy (Trinidad and Tobago, Antigua and Barbuda, Suriname, Dominican Republic, St. Kitts and Nevis, Grenada, among others). Through these instruments, governments direct the development of quality infrastructure.

They are dynamic systems, as they emphasize the performance of the components and how they interact with each other to provide results that are greater than what could be achieved by the components or parts working individually.

Conformity Assessment Bodies (CABs), which include testing and calibration laboratories, certification, verification and inspection bodies, work on the basis of harmonized international standards, ensure the traceability of measurements within the framework of the International System of Units, demonstrate their independence, impartiality and technical competence through accreditation, and are also service providers of the quality infrastructure.

To this must be added the promotion of quality thinking and the training or sensitization of the actors in the system.

These services not only serve to support companies in a specific sector, but can be beneficial for many actors and companies in different sectors. This is why, although the initiative to develop a certain quality infrastructure service may be driven by a particular sector, it may also have effects on other sectors (ECLAC, 2012).

Finally, the users of the national quality infrastructure system are businesses and consumers. For example, throughout their supply chains, companies use certifications to demonstrate the conformity of their products and services with customer requirements, they also demonstrate to government agencies that their products and services comply with technical regulations on safety, health and environmental protection. This applies to both exports and the domestic market.

Companies also benefit from the knowledge contained in the standards. Management system certifications also provide platforms for operational and social innovation.

The beneficiaries of the entire quality improvement system are the consumers, as they are provided with safe and safe quality products and services.

For the system to work, it is important that consumers are informed and aware of the quality labels, requirements and characte- ristics of the products or services and make their purchasing decisions accordingly.

To illustrate the target groups[41] present in a quality infrastructure, the following are mentioned:

- Companies and producers in agriculture, forestry, fishing, handicrafts and commerce, who benefit from a commercial sector regulated by reliable quality infrastructure services.

- Small and medium-sized companies that, unlike large companies, do not have their own calibration and testing capabilities and can rely on the su-pport of central entities in the quality infrastructure. A key factor is that this allows them to increase sales of their products by beingable to show proof of their quality.

- Domestic trade and exports/imports, which require testing services for e.g. quantity or quality inspections or verifications.

- Regulators, who can rely on this infrastructure and thus avoid duplication of facilities and services, particularly in countries with limited resources.

- Research and development in companies, as they will have better access to all quality assurance components.

- Scientific and academic community, which relies on reliable and internationally recognized measurements and test procedures.

- Financial institutions, which will be more inclined to grant loans to companies capable of showing quality certifications.

- Insurance companies, which could offer better premiums to those who meet quality standards.

- Arbitration bodies for commercial disputes, both national and international.

In short, the target group, in addition to the aforementioned actors, is the general population, which participates openly and has an impact on the dynamics of the labor market.

Now, when it comes to global collaborative relationships established between organizations such as ISO, IEC and ITU (international standards bodies), IAF and ILAC (international accreditation collaborations) and BIPM and OIML (international metrology organizations), at the regional level there is Quality Infrastructure Council of the Americas (QICA).

QICA promotes mutual collaboration and the exchange of experiences[42] to deve-

41 Sanetra, C., Marbán, R. (2007). Facing the global quality challenge: A National Quality Infrastructure, Physikalisch-Technische Bundesanstalt (PTB).

42 United Nations Industrial Development Organization. 2017. Quality infrastructure of the Americas: Strategic Roadmap. Vienna, Austria.

lop projects, share information, promote training activities and stimulate multi-functional development through its members such as the Pan American Standards Commission (COPANT), the Inter-American Metrology System (SIM) and the Inter-American Accreditation Cooperation (IAAC). These, in their synergistic relationship, contribute to the work of international organizations and, in turn, coordinate activities and initiatives with organizations at the national level (ONN, ONA, INM).

The following figure depicts the collaborative relationships at their different levels of intervention:

Figure 5. **Collaborative relationships between quality infrastructure organizations at national, regional and global levels**

Source: UNIDO, 2017.

SOURCE: MYRIAM BORZEE/ISTOCKPHOTO

Responsible purchasing seeks to integrate social, economic and environmental aspects into purchasing decisions.

This cooperation at the national, regional and global levels benefits all countries in terms of alignment with international standards and conformity assessment processes, including measurement services. It grants greater confidence regarding compliance with requirements in products and services-which makes them more competitive and organizations more sustainable-, increased access to international markets and improved quality of products and services available to citizens (UNIDO, 2017).

International technical cooperation and the exchange of experiences between countries and stakeholders strengthen the implementation of quality infrastructure. This creates new links that facilitate support opportunities such as, for example, access to external technical expertise, mutual support in the design of public policies or national strategies, and easy access to information, among others. In consideration of the complementarity that exists between the quality infrastructure systems and the circular economy, as well as various milestones that have driven the work towards sustainable development, this interrelationship over time is denoted (see Figure 6).

Figure 6. **Milestones of joint work between quality infrastructure and the circular economy**

1971
First two ISO Environmental Technical Committees for air and water

1987
Brundtland Report and Montreal Protocol

Launch of the ISO 9001:1987 Quality Management Systems Standard

1988
The Intergovernmental Panel on Climate Change (IPCC) is formed

1989
Basel Convention

Hazardous waste disposal

1992
Earth Summit in Rio de Janeiro Agenda 21

1996
Launch of the Environmental Management Systems Standard (EMS) ISO 14001:1996

1997
First version of ISO 14040 Environmental management

Life cycle analysis

Principles and frame of reference

Kyoto Protocol

Greenhouse gases

1999
United Nations Global Compact Movement that coordinates efforts of companies

2011
Launch of the Energy Management Systems (EMS) Standard ISO 50001:2011

2015
Paris Agreement: 195 countries adopt the firts legally binding global climate agreement

2019
Conformation of the International Committee ISO/TC 323 Circular Economy

2021
London Declaration

ISO General Assembly: Climate Action

Glasgow COP26

Results achieved from the Paris Agreement

2022
UNEP50 Nairobi historic agreement on plastic pollution

Source: Harmes-Liedtke, U. 2022.

3.1.1 Standardization

Standardization is a component of the quality infrastructure that promotes the use of technical standards. These are documents that establish requirements, specifications, guidelines or characteristics that can be used to ensure, on a consistent basis, that a product, process or service is suitable for its intended use or purpose.

They are established by consensus among interested parties, are approved by recognized standardization bodies, are available to the public and are used in the evaluation of products, processes or services.

For companies, they are strategic tools that reduce costs by minimizing waste and errors and increasing productivity. They also help them access new markets, level the playing field for developing countries and facilitate free and fair trade.

In terms of their nature, international standards and most national standards are implemented on a voluntary basis by organizations. Technical regulations are approved by governments and are mandatory in nature. It is good practice to take existing standards into consideration as a basis for the development of technical regulations.

This prevents technical regulations from imposing technical barriers to trade and unnecessary restrictions on companies.

In this regard, the World Trade Organization (WTO) established the Agreement on Technical Barriers to Trade (TBT Agreement). Its objective is to ensure that technical regulations, standards and conformity assessment procedures are not discriminatory and do not create unnecessary obstacles to trade. At the same time, it recognizes the right of WTO members to apply measures to achieve legitimate regulatory objectives, such as the protection of human health and safety or the protection of the environment.

The TBT Agreement strongly encourages members to base their measures on international standards as a means of facilitating trade. The transparency provisions of the agreement are intended to create a predictable trading environment.

As for private norms and standards, within the WTO TBT agreement there is a Code of Good Practice for the elaboration, adoption and application of standards. It is developed with the participation of all interested parties by the International Organization for Standardization (ISO) and its regional and national member organizations.

In addition, there are private standards developed by private companies and associations (Potts et al., 2014). This group also includes sustainability standards.

SOURCE: IPUWADOL/ISTOCKPHOTO

Review of quality management standards.

The challenge is to make both systems of standards compatible, to balance the cost-benefit ratio and to generate confidence in the whole system (ISO, 2011).

It should be noted that the efficient and reliable operation of production systems implies compliance with the norms, standards and/or regulations pertinent to the needs of each country or region.

3.1.2 Metrology

The International Bureau of Weights and Measures (BIPM), through the Joint Committee for Guidelines in Metrology - Working Group 2 (JCGM/WG2), defines metrology in the International Vocabulary of Metrology (VIM) as the science of measurements and their applications[43]. It encompasses all types of measurements with any level of uncertainty in any field of science and technology.

Metrology considers three fundamental activities:

- Definition of internationally accepted units of measurement for all quantities subject to measurement.
- Realization of these units of measurement in practice. That is to say, definition of the experiences through which the unit in question or a multiple or submultiple is obtained as a result.
- Dissemination of units of measurement through uninterrupted and documented chains of comparisons (made through measurements) that link the results of a measurement, in particular with the internationally

43 International Vocabulary of Metrology - Fundamental and General Concepts and Associated Terms (VIM) Spanish translation of VIM-3rd. 2008.

recognized reference for the quantity involved in the measurement made. Each of the measurements in the chain must have a given uncertainty. This chain is known as metrological traceability.

A national metrology system is divided into three fields:

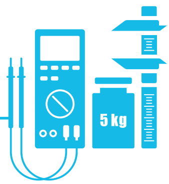
Scientific metrology

Is responsible for the definition and reproduction of measurement units through research for the development of new measurement methods, the creation of measurement standards, and the transfer of the traceability of these standards to users and society. The National Metrology Institute (NMI) is responsible for this task in each country. The competence of an NMI to provide reliable measurements with established levels of uncertainty is recognized by other NMIs in the world through the so-called International Committee of Weights and Measures Mutual Recognition Agreement (CIPM MRA), in cases where the NMI in question is a signatory to this agreement. In this regard, the BIPM maintains a database[44] of the metrological measurement and calibration capabilities of national metrology institutes around the world that have gone through the recognition process established in the CIPM MRA.

SOURCE: SAE, 2022.

Calibration of measuring instruments of electrical quantities.

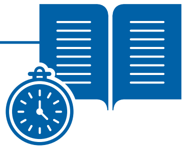
Industrial metrology



It is responsible for promoting confidence in the measurements made in the different industrial processes, laboratories and other organizations. This is done by ensuring the quality and traceability of these measurements through the periodic calibration of their measuring instruments against standards traceable to the International

System of Units (SI). This confidence is the basis for improving industrial competitiveness, health and safety in a country (reliable data generates reliable decisions). Industrial metrology is generally carried out in countries by secondary calibration laboratories. In order for their technical competence to be recognized internationally, they must go through an accreditation process.

Legal metrology



Is the part of metrology related to the activities that derive from the legal requirements applied to measurement, units of measurement, measuring instruments and methods of measurement. They are carried out by the bodies designated as competent in each country. It is the responsibility of governments to protect the rights of citizens with regard to commercial transactions and health issues. The measuring instruments involved in these aspects are involved through regulations that are approved for each type of instrument at the national level (regulated instruments). For the establishment of the national measurement system, the National Metrology Institute (INM) is responsible for maintaining, developing and disseminating measurement standards and metrological knowledge in each country. They provide calibration services to secondary calibration laboratories and other organizations responsible for legal metrology.[45]

Metrology, in any of its fields of action, ensures technical certainty and confidence that products or services immersed in local and global value chains comply with established quality requirements. This is achieved through reliable measurements of parameters that ensure such compliance.

Metrological traceability of measurements to the International System of Units is a fundamental requirement of a number of ISO/CASCO and other ISO standards, such as ISO 9001 and product standards.[46]

44 **https://www.bipm.org/kcdb/**
45 United Nations Industrial Development Organization. 2017. Quality infrastructure of the Americas: Strategic Roadmap. Vienna, Austria.
46 Idem.

3.1.3 Accreditation

ISO/IEC 17000:2020 defines accreditation as the "third party attestation related to a conformity assessment body, which conveys formal demonstration of its competence, impartiality and consistent operation in the performance of specific conformity assessment activities".[47]

As mentioned at the beginning of this chapter, CABs are testing laboratories, calibration laboratories, medical laboratories, reference material producers, proficiency testing providers, and certification and inspection bodies whose purpose is to demonstrate compliance with specified requirements relating to a product, process, system or organization.

SOURCE: IAAC, 2019.

IAAC General Assembly held in Mexico City in 2019.

Within this framework, accreditation is assumed by the Accreditation Bodies (AB) which, depending on their scope and country interests, can have international recognition through Multilateral Recognition Agreements (MLA) with other AB within the frameworks of the International Accreditation Forum (IAF)[48] and Mutual Recognition Agreements (MRA) in the International Laboratory Accreditation Forum (ILAC).[49]

These recognitions operate through regional cooperations such as IAAC, EA, APAC, among others. The international recognition of accreditation scopes is an effective instrument that facilitates commercial exchange between countries, since, with a single demonstration of compliance with product or service requirements in one country, the recognition of compliance is assured in the countries that have MRA signatory organizations.

MRAs established between IAF and ILAC members foster collaboration to improve accreditation and conformity assessment globally. They reduce risk to business, regulators and the consumer, ensure that accredited services can be trusted, make it easier for governments to further develop or improve trade agreements, and support freedom of global trade by removing unnecessary technical barriers.

Accreditation also coordinates efforts with standardization and metrology. IAF and ILAC work closely with the international institutions for standardization and metrology, such as ISO and BIPM. At the regional level, IAAC collaborates closely with its counterparts in the regional quality infrastructure: COPANT and SIM.

It should be noted that conformity assessment standards and their interrelationship with the quality infrastructure in general have contributed significantly to sustainable development. For example, in defining procedures for determining the conformity of products, processes and systems. They will continue to play a role in facilitating the achievement of SDG 9 on industry, innovation and infrastructure and the rest of the SDGs of the 2030 Agenda.

There is a growing awareness of the role of conformity assessment standards for most of the SDGs in helping to determine the extent to which all relevant sustainability stakeholders are achieving their stated goals and objectives.

The balanced implementation and efficient operation of standardization, metrology, accreditation and conformity assessment in each country promotes quality and competitiveness and, consequently, facilitates integration into the different value chains.

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47 **https://www.iso.org/obp/ui/#iso:std:iso-iec:17000:ed-2:v2:en**

48 https://iaf.nu/en/home/

49 https://ilac.org/

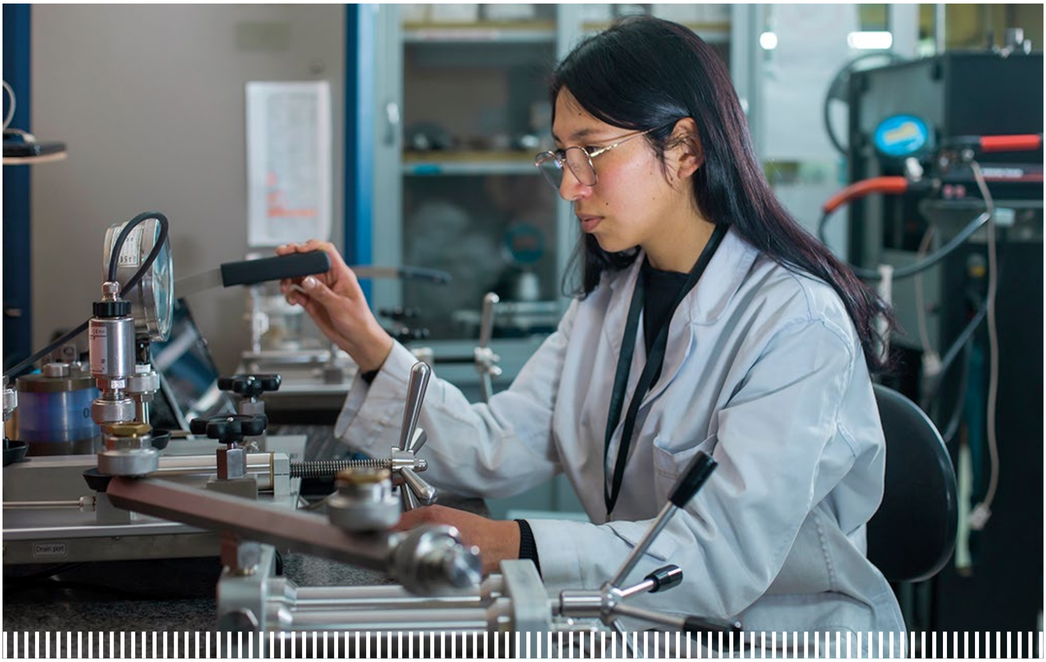
Regional context of the quality infrastructure

All countries in Latin America and the Caribbean have at least one agency responsible for at least one of the three pillars of quality infrastructure. And almost all countries in the region have agencies responsible for each of the three pillars.

These institutions are organized at the regional level in three specialized organizations: COPANT for standardization, IAAC for accreditation and SIM for metrology.

Together, national agencies form a national quality infrastructure system linked through cooperation to contribute significantly to building confidence in international action. In this way, regional organizations provide mechanisms for the

SOURCE: CENAM, 2022.



recognition of accreditations between countries, for the harmonization of standards, for traceability and recognition of measurements.

The functions of each of the international and regional quality infrastructure organizations, as well as others involved, are described below:

Table 1. **Main functions of international and regional organizations of quality infrastructure**

CI component	Organization	Main functions
Accreditation	**IAF (International Accreditation Forum)**	The International Accreditation Forum (IAF*) is an international organization comprised primarily of national accreditation bodies from around the world covering the scope of accreditation of certification, verification and validation bodies. Those members that have received peer evaluations and have been determined to be competent and reliable sign the Multilateral Recognition Agreement (MLA). The MLA assures and commits the signatories to recognize the accreditation certificates of the other signatories and, with it, the certificates issued by the Conformity Assessment Bodies accredited by all signatories. The MLA is administered by the IAF and relies on regional bodies such as the IAAC.
	ILAC (International Laboratory Accreditation Cooperation)	The International Laboratory Accreditation Cooperation (ILAC) is an international organization comprised primarily of national accreditation bodies from around the world covering the scope of accreditation of calibration, testing and clinical laboratories, as well as inspection bodies. Those members that have received peer evaluations and have been determined to be competent and reliable sign the Mutual Recognition Arrangement (MRA). The MRA ensures and commits signatories to recognize the accreditation certificates of other signatories and, with it, the certificates issued by the Conformity Assessment Bodies accredited by all signatories. The MRA is administered by ILAC and is supported by regional organizations such as IAAC.

CI component	Organization	Main functions
Accreditation	**IAAC (Interamerican Accreditation Cooperation)**	The Inter-American Accreditation Cooperation (IAAC) is a regional organization composed mainly of national accreditation bodies. Among its main functions are to promote, organize and ensure regional and international recognition of the accreditations granted by its members, as well as to develop accreditation and conformity assessment infrastructure in the region. Note: As well as IAAC acts for the Americas region, there are other associations for other regions, for example, EA for the European region, APAC for the Asia Pacific region, ARAC for the Arab countries, AFRAC for Africa, and SADCA for Southern Africa.
Standardization	**ISO (International Standardization Organization)**	The International Organization for Standardization (ISO) is an independent international organization with a presence in 193 countries. Its committees bring together technical experts from around the world to develop international standards. More than 22,000 ISO standards have been drafted, covering all industries: agriculture, energy, technology, among others. Among the main contributions of ISO standards are to promote the development of territories, to make trade between countries fairer and more transparent, and to promote efficiency and effectiveness in production processes and the provision of services.
	IEC (International Electrotechnical Commission)	The International Electrotechnical Commission (IEC) is an organization of more than 170 countries concerned with the quality infrastructure and international trade in electrical and electronic products. The IEC provides a global, independent standardization platform and also administers four conformity assessment systems whose members certify devices, systems, installations, services and people.

CI component	Organization	Main functions
Standardization	**CODEX**	It is a commission for international food standards. Its members can be all those interested in food standards who participate in the FAO (Food and Agriculture Organization of the United Nations) and WHO (World Health Organization).
	COPANT (Pan-American Commission for Technical Standards)	The Pan American Standards Commission is a non-profit civil association that brings together the national standards bodies (NSBs) of the Americas (32 active members and 10 adherent members). COPANT is the reference for technical standardization and conformity assessment of the countries of the Americas and its international peers, and promotes the development of its members.
Metrology	**BIPM (International Bureau of Weights and Measures)**	The International Bureau of Weights and Measures (BIPM) is an international organization established by the Metre Convention through which member states act together in matters related to metrology and measurement standards. It has 63 Member States and 38 Associate States. It represents the world metrology community. It is the center of scientific and technical collaboration among member states by providing capabilities for international measurement comparisons. In addition, it is the coordinator of the world measurement system, ensuring comparable and internationally accepted measurement results. Together with all regional metrology organizations worldwide, it manages the CIPM Mutual Recognition Arrangement (CIPM MRA).
	OIML (International Organization of Legal Metrology)	The International Organization of Legal Metrology is empowered to support economies in establishing effective legal metrology infrastructures that are mutually compatible and internationally recognized. This applies to all areas for which governments assume responsibility, as well as to those that facilitate trade, establish mutual confidence and harmonize the level of consumption.

CI component	Organization	Main functions
Metrology	**SIM (Inter-American Metrology System)**	The Inter-American Metrology System integrates the organizations responsible for metrology in the Americas and strategic counterparts (National Metrology Institutes and designated institutes and organizations responsible for legal metrology). It is organized into five sub-regions: NORAMET, CARIMET, CAMET, ANDIMET and SURAMET. Its objective is to improve the regional measurement infrastructure to boost global competitiveness and quality of life.
Other organizations involved	**WTO (World Trade Organization (WTO)**	The World Trade Organization (WTO) is an international body that provides the organizational framework for the creation and enforcement of global trade law within and by its member states. Its functions include reviewing the trade policy of its members, assuming administrative and supervisory functions, and serving as a key vehicle for negotiations between governments.[50] To ensure that technical regulations, standards and conformity assessment procedures are non-discriminatory and do not create unnecessary barriers to trade, the Agreement on Technical Barriers to Trade[51] (TBT Agreement) is established. It is an integral part of the World Trade Organization Agreement and is therefore legally binding for all its members. This agreement recognizes the right of WTO members to implement measures to achieve legitimate policy objectives, such as the protection of human health and safety or the protection of the environment.

Note: since IAF and ILAC have continuously coordinated efforts to improve accreditation and conformity assessment, they are in the process of merging into a single organization.

50 Djazayeri, A. 2012. Main Features of World Trade Law with special focus on the TBT Agreement: A guideline. Physikalisch-Technische Bundesanstalt. Braunschweig, Germany.

51 The Agreement on Technical Barriers to Trade applies to all technical regulations, standards and conformity assessment for all kinds of goods, including industrial and agricultural products. It excludes sanitary and phytosanitary measures, which are covered by a separate agreement.

In many of the smaller countries, the institutions of quality infrastructure (standardization, metrology, accreditation) are under one roof (see, for example, the national standardization offices in the Caribbean). In the larger countries, different configurations are found.

In Brazil, scientific and legal metrology and accreditation are part of INMETRO (National Institute of Metrology, Quality and Technology) and standardization belongs to ABNT (Brazilian Association of Technical Standards). In the Dominican Republic, metrology and standardization are part of INDOCAL (Dominican Institute for Quality) and the Dominican Accreditation Body (ODAC) is independent. In the case of Colombia, with ICONTEC (Instituto Colombiano de Normas Técnicas y Certificación), INM (Instituto Nacional de Metrología de Colombia), the Superintendencia de Industria y Comercio (SIC) responsible for Legal Metrology and ONAC (Organismo Nacional de Acreditación de Colombia) each component of the quality infrastructure has its own organization.

Regardless of the form of organization defined by each country, it is very important to establish roles in the quality infrastructure institutions according to their competence.

The National Standards Bodies collaborate in COPANT, the IAAC is the cooperation of the accreditation bodies and the National Metrology Institutes collaborate in SIM. Together, COPANT, IAAC and SIM form the Quality Infrastructure Council of the Americas (QICA). This gives the region's quality infrastructure a common contact and communication platform. Within the framework of QICA, the quality infrastructure agencies also implement regional international development cooperation projects (see Annexes).

4

What is the contribution of quality infrastructure to the circular economy in the Latin American and Caribbean region?

In view of the interest in the specific contributions of quality infrastructure to the circular economy, a systematic collection and analysis of scientific literature on the circular economy was carried out.

We also interacted with actors in the circular economy and quality infrastructure from more than 20 countries in the region through workshops developed within the framework of the Quality Infrastructure for Circular Economy in Latin America and the Caribbean (QI4CE LAC) project.

The application of this participatory approach in the sense of action research makes it possible to involve project participants in the study process and in the implementation of results. Sandín (2003, cited by Wilfred Carr, 2007, p.22) argues that action research builds knowledge through practice and is not outside the actors themselves. This type of research also favors the collaboration of stakeholders in the identification of needs and the formulation of possible solutions.

To introduce the benefits offered by the components of the quality infrastructure to the circular economy, it should be noted that, through standardization, there is access to national and international information on the state of the art of products, processes and conformity assessment procedures. The standardization process ensures national and international harmonization as a result of consensus with

METROLOGY AND TESTING LABORATORIES PERFORM MEASUREMENTS, WHICH ARE THE TECHNICAL BASIS FOR ALL REQUIRED TECHNOLOGICAL DEVELOPMENT WITH RECOGNIZED COMPETENCE THROUGH ACCREDITATION.

SOURCE: SAE, 2022.

Scientist conducting test trials for food product development.

stakeholders. Metrology and testing laboratories perform measurements, which are the technical basis for all required technological development with recognized competence through accreditation.

Conformity assessment laboratories and bodies assess whether products, processes and procedures comply with the requirements specified in norms, technical regulations or other defined standards.

Through accreditation, confidence in the system and recognition of certificates, seals, labels or other declarations of conformity in the national and international market is achieved.

Within this framework for action, six major needs of the circular economy in the region are identified, to which quality infrastructure can make a specific and significant contribution:

1 Harmonized terminology and conceptual clarity on the circular economy

Definition of the circular economy and its levels of implementation.

Harmony between terms related to the circular economy.

Conceptual basis from the life cycle perspective and sustainability.

2 Production culture and responsible consumption

Informed and aware citizens.

Good practices for circular production.

New business models.

Accessible markets for new materials, products and services.

3 Enabling public policies and regulatory framework

Political will.

Regulatory framework with a systemic, transversal and consistent approach to market dynamics.

Stakeholders involved in the design and formulation of public policies (inclusive governance).

Articulation and multilevel collaboration (local, regional, national and international.

Source: own elaboration, 2022.

4 Trust, traceability and interoperability of information

Reliable methodologies and tools for measuring and evaluating circularity.

Standardized and comparable circularity indicators.

Traceable declarations and certifications (stamps, certifications circular economy, materials passport, among others).

Interoperability between actors, systems, processes, products and services.

5 Competitive products and services

Competitiveness and positioning of micro, small, medium and large companies.

Efficiency of management processes, logistics, production and monitoring.

Safety, quality and performance requirements based on established standards.

Agile and accessible services (value chain and network).

6 Scientific, technological and innovation base

Scientific and applied research as a link between science and society.

Appropiate, efficient and low-cost technologies.

Innovation management.

Digital transformation.

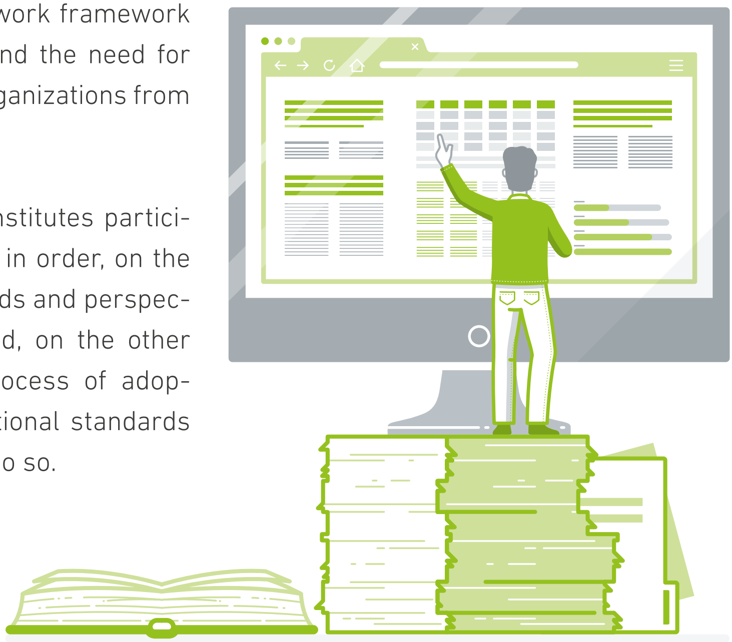
1 Harmonized terminology and conceptual clarity on the circular economy

The contribution of quality infrastructure to this need is as follows:

At the international level, within the framework of ISO, terminology is being harmonized and definitions related to the circular economy are being established through the Technical Committees ISO/TC 207, ISO/TC 323, ISO/TC 322, among others. The standards directly related to the circular economy are ISO 59004, ISO 59010, ISO 59020, ISO 59040, 59014 and supporting documents. Likewise, the ISO standards already published and linked to sustainable development, life cycle, management systems, among others, as well as the standards under development, have the opportunity to generate a joint work framework given their interrelation and the need for their implementation in organizations from a systemic approach.

The National Standards Institutes participate in these committees in order, on the one hand, to bring the needs and perspective of their countries and, on the other hand, to facilitate the process of adopting ISO standards as national standards where it makes sense to do so.

Internationally harmonized standards provide a trusted global framework that can be used by industry, governments and stakeholders to accelerate the implementation of the circular economy. They provide a good basis for cooperation between countries for, for example, programs to promote the circular economy and without creating unnecessary technical barriers to trade.



2 Production culture and responsible consumption

The contribution of the quality infrastructure in response to this need is as follows:

The concepts of responsible production and consumption are closely linked to the quality infrastructure. It is not possible to deal with issues of responsible production and consumption if there are no standards, accredited certification mechanisms, measurements in processes and laboratories used, for example, to label products to ensure public confidence.

Therefore, awareness-raising, dissemination and training activities that promote the circular economy find, in the standards, information that reflects the state of the art, which has been developed based on a consensus process and whose characterization of products, processes and procedures is accepted in national and international markets.

Successful experiences and good practices in circular production to be disseminated include the use of standards, calibrated equipment and accredited laboratories, certifications, seals and labels that can be promoted and transferred to a larger group of companies through standards and good practice guides. In this way, micro, small and medium-sized enterprises can be given access to these good practice guides and, in turn, to other quality infrastructure services. This is the case of the use of accredited certification of products or services, which not only creates confidence for buyers and consumers, but also ensures transparency in the market.

Likewise, the standardization work through its committees and the interaction between the committees achieves interoperability between the standards that are produced. This facilitates the management of the complexity that characterizes the circular economy.

New business models and their development rely on standardization and accredited conformity assessment to ensure, and then demonstrate, that their products or services meet regulations and the quality expectations of consumers and users, regardless of their sector. For example, a business model that manages construction and demolition waste for the production of environmentally friendly bricks or blocks can reduce time to market acceptance by demonstrating that its end product meets established quality requirements. This generation of confidence in compliant products can be used by programs and initiatives that promote the inclusion of the informal sector and actors with little recognition in the local market.

The training is based on the contents of the standards and/or guidelines, promotes the implementation of adapted management systems and good practices to objectively and constantly evaluate the conformity of the products and services offered by these actors-thus creating a virtuous circle towards a circular economy that complies with the logic of diversity and social inclusion.

On the other hand, it is important to raise awareness, since efficient industrial processes can only be achieved by implementing adequate measurements of critical parameters at each stage. Only by having processes where the critical parameters are controlled through reliable measurements will products that consistently meet specifications be achieved, minimizing waste and rework. Since metrology plays a fundamental role in this sense, it is necessary to accompany it with awareness processes on the importance of reliable measurements to ensure the efficiency of processes, products or services.

The market for new materials, products or services must not only be transparent, but must also allow for efficient transactions. To this end, it is necessary to reduce the asymmetry of information on the origin and quality of these new materials, products and services. Standardized documentation of requirements, appropriate measurement of requirements and accredited conformity assessment certificates offer a solution to this challenge.

3 Enabling public policies and regulatory framework

Some guidelines for this need from the quality infrastructure are:

The regulatory framework should define minimum requirements and permissible limits for contamination of materials, products and processes to protect consumer rights, health and the environment. It is good practice to base and reference laws, regulations and standards of a province, city, state, municipality, country or other on national or international standards, as well as to use the installed metrological structure and accredited conformity assessment capacity to avoid creating unnecessary technical barriers to trade or stifling innovation.

The standardisation processes driven by ISO through the ISO/TC 207, ISO/TC 322 and ISO/TC 323 Technical Committees seek to design and develop guidance, taxonomy and implementation tools to contribute to government and industry compliance with the SDGs. When public policies use these and other standards as a technical basis, they ensure that they build an information base and definitions that reflect the national and international state of the art, that ensure interoperability between the different sectors involved and to be involved, and that has been elaborated with the participation of stakeholders in a consensus process.

Through their regional (COPANT, IAAC, SIM and QICA) and international networks, quality infrastructure institutions are also a source of information and experiences based in other countries to be consulted for designing national public policies. Bringing the circular economy to life requires articulating actors, sectors, value chains and networks, including those that traditionally do not interact with each other. This must occur at local, national, regional and international levels to increase complexity.

Standardisation is not only supported by existing standards that ensure consensual and articulated standardisation at all levels. It also, through its technical standardisation committees with expertise in considering the interests and needs of stakeholders and defining criteria in a consensual manner, offers to develop new standards and packages of standards according to the conditions that result in the implementation of the circular economy.

4 Trust, traceability and interoperability of information

The quality infrastructure contributes to trust, traceability and interoperability of information in the following ways:

On the one hand, methodologies and tools for measuring and evaluating circularity, as well as circularity indicators, can be defined based on national and international standards. For example, in eco-design standards, life cycle of products and services, environmental footprint. This ensures harmonization and comparability and acceptance of the criteria by the different stakeholders, including those at the international level.

On the other hand, a circularity assessment of products, services, companies, etc. supported by metrology and accreditation ensures that the measurement and assessment of circularity, as well as the determination of indicator values, is performed in a competent and comparable manner.

All of this helps to build trust and ensure traceability of information and circularity claims, be they seals, circular economy certifications, material passports, etc.

Likewise, through the technical standardization committees and the interaction between them, the interoperability of product, process, procedure and management system standards is ensured. As an example, we can mention the agile integration of ISO management systems such as the Quality Management System (ISO 9001:2015) and the Environmental Management System (ISO 14001:2015).

Metrology, on the other hand, ensures the comparability and interoperability of measurements through the traceability of all measurements to the International System of Units and the use of standardized formats for the documentation and management of metrological data and information.

5 Competitive products and services

The contribution of quality infrastructure to this need is as follows:

Companies that use product, process and management standards not only reduce costs and ensure the quality of their products and services, but also achieve better positioning in the market. For this, in addition to standards, it is also important to have the support of metrology and accredited conformity assessment. With reliable measurements and tests, they can first comply with the standards and then demonstrate it and have the corresponding reliable certificates. All this contributes to improving their competitiveness, regardless of the size of the company.

Standards and their implementation, in addition to improving processes and management in production units, improve the interaction between actors -for example, those involved in local and regional value chains-. In other words, transactions, logistics, division of labor and monitoring of impacts and other processes whose importance is growing in a circular economy become more effective and efficient, since the criteria and the way of assessing compliance are standardized.

In order to achieve competitive companies, sectors and countries, technical regulation (safety and security requirements) and standardization (quality and performance requirements) must interact with each other. On the one hand, existing and future technical regulations, as well as international standards, are considered in all standardization processes. On the other hand, it is good practice for technical regulations to use national and international standards as a basis, making reference to them. This ensures that mandatory and voluntary requirements do not contradict each other, but rather complement each other.

Finally, actors in the circular economy require that standards development, measurement and calibration, and conformity assessment services are not only reliable, but also accessible and agile. The quality infrastructure is using digital transformation to improve its processes and the accessibility of its services.

6 Scientific, technological and innovation base

The contribution of quality infrastructure to this need is as follows:

The processes of scientific research and technological development with respect to primary and secondary materials should be based on the national and international state of the art. Standards and experts from technical standardization committees are a reference source to know the state of the art and research needs.

Calibration and testing laboratories, as well as the National Metrology Institute, can be allies to implement processes in research and development of appropriate technology where, in addition to laboratory services, the expertise of laboratorians and metrologists is required. In addition, quality infrastructure institutions have access to advanced scientific and technological developments through their regional and international networks.

Likewise, standardization supports the use of secondary and primary materials from two angles. On the one hand, standards define the requirements that materials must meet or not meet in order to be integrated into a specific process or product. On the other hand, standards characterize materials. Metrology and testing laboratories intervene with their competent services in the definition of requirements and characterization. And then, conformity assessment demonstrates whether the materials offered meet the requirements established in the market, thus ensuring the innovation process.

The ISO 56000 series of standards can support the effectiveness and efficiency in the management of innovation processes within and outside organizations. They also maximize the added value of the management system and facilitate national and international business operations.

Digital transformation is a key tool for the circular economy to materialize more broadly in Latin American and Caribbean

countries. (Pagoropoulos, A., et al. 2017) argues that while there is general agreement on the role of digital technologies in the transition to a more circular model, and while their importance is not disputed, the level of maturity of digital technologies is questioned, which is why different application scenarios remain to be analyzed.

It is also reflected that the quality infrastructure, once strengthened by the digital transformation-digital standards, remote measurements and calibrations, remote assessments, digital certificates, etc.-will be able to ensure that the generation, management and use of the information needed in the framework of the circular economy is accessible, agile and reliable.

5

Conclusions and recommendations

This study describes the interrelationship between the circular economy and quality infrastructure. It demonstrates that quality infrastructure, with its services, can contribute significantly to the development of the circular economy. Taking into account the special conditions of Latin America and the Caribbean, it explains the needs of the circular economy and their possible satisfaction through quality infrastructure.

Quality infrastructure will play a key role in supporting the development of the circular economy concept in the regional context and in its implementation. It will generate new quality products and services for the circular economy in multiple sectors such as plastics, construction, textiles, agriculture, tourism, food systems, among others.

The concept of the circular economy at the regional level is in the process of consolidation among the different stakeholders towards a more systemic approach. This will result in important challenges for the promotion and prioritization of future programs and projects, standards, development of measurement and evaluation tools, awareness processes in urban and rural areas, and mobilization of resources and incentives.

The systems approach where both quality infrastructure and the circular economy operate represents a clear opportunity for shared value creation and impact on international trade.

The circular economy represents a strategic means to achieve the Sustainable Development Goals of the 2030 Agenda and the Paris Agreement.

From the approach with stakeholders and the collection of information, the need to promote social value from the circular economy is highlighted. Although it is a topic that is little discussed in circular practices, where environmental and economic benefits are more frequently addressed, social impact is crucial to integrate all links in the value chain by listening to their needs, providing better job opportunities and, thus, building or rebuilding relationships with actors in informal economies and local communities, giving them an active role in emerging business models.

The establishment of international circular economy standards promoted by the International Committee ISO/TC 323 will harmonize the frameworks in terms of concepts, strategy and implementation based on measurement and evaluation tools. Each country will be responsible for applying the standards according to its own reality and/or needs. Likewise, it is important to design and develop reliable and traceable circularity methodologies and tools that contribute to the achievement of objectives and goals at the different levels of implementation of the circular economy.

ISO standards do not regulate or legislate. However, despite their voluntary nature, they can become a market requirement, as has happened with the ISO 9001 Quality Management System, the ISO 14001 Environmental Management System and the implementation of integrated management systems.

Bottom-up implementation of the circular economy will take place if micro, small, medium and large enterprises, startups, ventures and their interaction with each other through business symbiosis promote collaborations with stakeholders, while generating decent employment and managing innovation.

The contribution of the circular economy to the social inclusion of disadvantaged sectors and the reduction of their vulnerability is a priority component considering the reality of labor markets in Latin America and the Caribbean.

Organizations with implemented management systems present greater opportunities to adapt their processes, procedures, services or others towards circularity, considering the existing interoperability in standards, actors, processes and future projects.

Latin America and the Caribbean face diverse socio-cultural, economic and environmental gaps towards sustainable economic recovery, and it can be difficult to leave behind traditional production and consumption habits. However, the circular economy is a responsibility to be assumed by all actors in the system - businesses, policymakers, citizens and civil society - with each contributing to the transition.

The quality infrastructure, through standardization, metrology, accreditation and conformity assessment, responds specifically and significantly to the needs of the circular economy. It is an important challenge to achieve the interrelation between both systems.

Users and consumers are increasingly aware of participating in dissemination and communication activities, purchasing products derived from local initiatives where fair trade is applied, and receiving specialized training. However, in most cases they are held back by lack of access to information and cost barriers. Public and private promotion and investment is needed to ensure the construction of a responsible and informed culture.

Digital transformation and the use of new technologies such as artificial intelligence, big data, internet of things (IoT), among others, become useful tools that facilitate access to knowledge, management and evaluation of the impact of the circular economy.

The study has systematically explained, for the first time, the connection between the circular economy and quality infrastructure. The Annexes section presents case studies showing these connections.

The team of authors hopes that this work will help to inform the promoters of quality infrastructure and the circular economy in the region, businessmen, entrepreneurs, public policy makers and professionals interested in the subject about the services provided by quality infrastructure and, thus, better strengthen the circular transformation. At the same time, it orients quality infrastructure actors on the needs of the circular economy that can be addressed by current services or by the development of new services.

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Anexxes

Annex 1.

Strengthening quality infrastructure in the WEEE value chain in Ecuador

GENERAL DATA

Country: Ecuador
Execution period: 2019-2020
Current status: completed

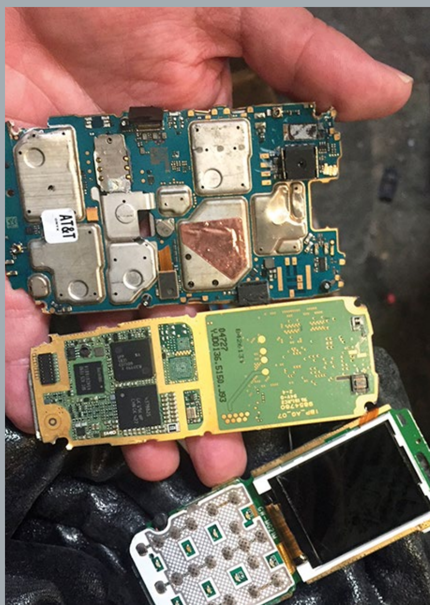
BACKGROUND

The national project to strengthen the infrastructure of the waste electrical and electronic equipment (WEEE) value chain, in application of the CALIDENA methodology[52], was developed within the framework of the regional project "Fostering Innovation for the Green Economy".

It included infrastructure in Latin America and the Caribbean and allowed observation of the process by quality infrastructure organizations from Argentina, Brazil, Colombia and Honduras.

The CALIDENA methodology was part of the e-waste management component of the project with a focus on the circular economy and secondary metals management. The team of facilitators consisted of Mauro Rivadeneira and Alexis Valqui.

SOURCE: PTB, 2019.



Review of equipment during the technical visit to the WEEE treatment plant.

52 The term CALIDENA comes from the combination of the Spanish words "calidad", which refers to the quality infrastructure, and "cadena", which refers to the value chain. It is a participatory methodology developed and implemented by the Physikalisch-Technische Bundesanstalt (PTB) and Mesopartner to stimulate quality in value chains. Its aim is to systematically and sustainably support quality infrastructure improvements.

It is worth mentioning that Ecuador has several environmental managers (recyclers) that carry out the recovery, primary treatment of these materials and certifications to subsequently manage the export of cards. The Ministry of the Environment, Water and Ecological Transition has worked on regulating the sector to protect natural resources and optimize waste management.

The quality infrastructure organizations have a good response capacity to support the necessary conformity assessment once the regulation is in place. The WEEE management culture in the country presents good prospects for repair and life extension.

At the national and regional level, there are deficiencies and limitations in terms of infrastructure for secondary metallurgy and metal recovery, which currently only exist in Europe. Therefore, cards continue to be exported and other components are recovered in Latin America for local use.

The use of manual labor for disassembly gives competitive advantages over recovery carried out in countries in the northern hemisphere.

OBJETIVES

The main objectives of the project are:

- Strengthening of Ecuador's quality infrastructure to support the WEEE value chain with a focus on the circular economy.
- Align CALIDENA methodology to circularity criteria.

JUSTIFICATION

Waste electrical and electronic equipment contains valuable metals that, in general, are not adequately recovered. In addition, when disposed of in landfills they can affect the health of the population and pollute the environment.

For this reason, this exercise was implemented to articulate public and private initiatives.

REFLECTION QUESTIONS

- Which actors are part of the WEEE value chain in Ecuador?
- What services can the quality infrastructure develop to improve current WEEE management?

UNIT OF ANALYSIS

All links in the WEEE value chain were analyzed, identifying quality infrastructure support needs and internal deficiencies.

The following actors participated:

- Ministry of Production, Foreign Trade, Investments and Fishing

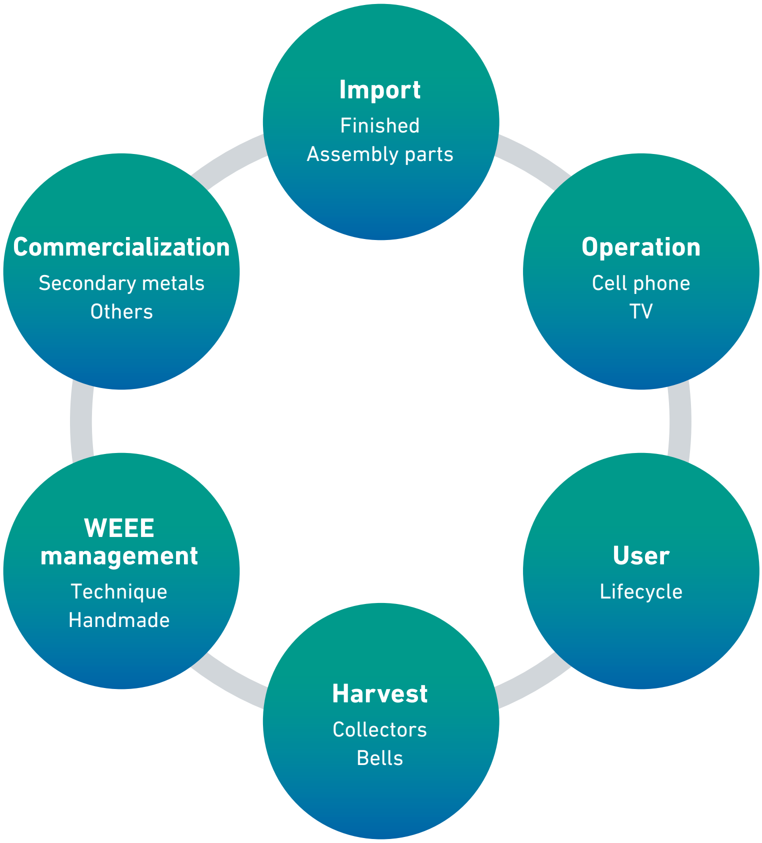
- Ministry of Environment, Water and Ecological Transition
- Ministry of Telecommunications
- Telecommunications Regulatory Agency
- Ecuadorian Accreditation Service
- Municipality of Quito, Environmental Directorate
- Producers and importers of cellular phones and televisions (Claro, ICESA)
- Environmental Managers (RENAREC and recyclers), Vertmonde, Reciclametal
- International observers (CESSCO, INMETRO, Instituto Nacional de Tecnología Industrial)
- University of Cuenca

DEVELOPMENT

The project was carried out following the stages defined in the CALIDENA methodology, which include:

- Feasibility study
- Central workshop held in the city of Quito
- Monitoring of the implementation of the CALIDENA action plan
- Impact assessment

The value chain map that was designed included representative actors and also representatives of state promotion and regulatory entities:



The value chain diagnosis ended with a vote to prioritize actions. The following intervention possibilities were obtained, in order of priority:

- Development of quality, safety and environmental management systems for WEEE managers.
- Visible support from authorities for recycling campaigns.
- Linking extended producer responsibility in regulation.
- Measurement and regulation of hazardous substances in import activities.
- Separation and reduction at source.
- Extended producer responsibility for television assemblers.
- Standardization of material requirements.
- Training for grassroots recyclers or waste collectors.
- RoHs directives, requirement 2011/65/EU, for the reduction of hazardous substances.
- Green or clean points for WEEE collection.
- Characterization of residual plastic.
- Development of good regulatory practices.

An action plan was defined and implemented for approximately one year, which included the following activities:

- Develop management systems for WEEE operators.
- To count on the support of authorities for the collection of WEEE in awareness campaigns.

SOURCE: PTB, 2019.

Technical visit to the WEEE treatment plant.

- Binding importers and assemblers of televisions within the framework of extended producer responsibility.
- Standardize and regulate the measurement or evaluation of hazardous substances.
- Reinforce separation and reduction at the source.

CONCLUSIONS

Ecuador's environmental authorities, at both the ministerial and municipal levels, supported the collection activities through dissemination and awareness campaigns.

SOURCE: PTB, 2019.

Presentation of the CALIDENA project at the launching workshop in Quito.

The managers involved improved their management systems with a focus on international certifications. However, it is necessary to extend it to a larger number of managers operating in the country.

The Ministry of Environment, Water and Ecological Transition issued a code with regulations that include extended producer responsibility for televisions and other WEEE categories. At the time of project implementation, cell phones were already covered by the regulations, which include the mechanism for evaluating hazardous substances.

The source separation and reduction mechanism has been partially developed considering that it requires many related activities.

LESSONS LEARNED

For the chain:

- Although waste pickers are grouped together, they do not carry out concrete activities as a group that would improve their level of integration and translate into better living conditions. Optimizing their processes through training activities, developing new skills and defining responsibilities are the most important elements of the value chain from the social and economic dimensions.
- Corporate social responsibility has steadily increased at the national level with a focus on the circular economy.

For the country's quality infrastructure:

- Coordination with value chains makes it possible to develop more competitive products.
- The promotion of the circular economy requires concrete actions from the quality infrastructure in terms of standards issuance, metrological traceability and conformity assessment with competent conformity assessment bodies.

For CALIDENA methodology:

- The alignment of the methodology demands that, in the analysis of the value chain, essential components such as eco-design, reduction practices, repair for life extension are included. In WEEE management, the life cycle is an essential factor.

- In the work team, it is important to include institutions and people with knowledge and authority in environmental and circular economy issues for the prioritization of future actions and related initiatives.

RECOMMENDATIONS

- The management systems and competencies of the personnel involved in the management links of the WEEE value chain must be improved.
- Sales and incentive mechanisms should be updated to improve managers' profitability.
- The relationship of the value chain with the quality infrastructure could be strengthened so that its services are more easily accessed.
- There is a high focus on regulation in the sector and it would be important to support the actors involved with WEEE management system certification.
- A very important aspect to consider in this project was the extension of the useful life of the devices, through repair or use with new users to replace them. It is hoped that new initiatives and business models related to the sector can be developed as next steps, supported by the articulation of actors that was worked on.

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CALIDENA Handbook 2.2. Physikalisch-Technische Bundesanstalt, German Cooperation, Ulrich Harmes-Liedtke, Reinhard Schiel, 2016.

Website: **https://www.calidena.ptb.de**

Annex 2.

Quality assurance in the measurements required for the determination of the biodegradability of chemical substances in Costa Rica

DATOS GENERALES

Country: Costa Rica
Execution period: 2018-2022
Current status: completed

BACKGROUND

During the 2018-2022 period, PTB implemented the project "Regional Fund Quality Infrastructure for Biodiversity and Climate Protection in Latin America and the Caribbean". Within the framework of the subproject Biodegradability: a path towards the responsible use of organic chemicals, the opportunity to extend the impacts to the Costa Rican level was identified, due to the fact that the country in the last decade has generated legal and technical tools that allow consumers and industrialists to take into account the environmental performance characteristics of consumer products.

SOURCE: LACOMET, 2019.

Presentation of the CALIDENA methodology.

CALIDENA was developed in line with the National Policy on Sustainable Public Procurement, issued by the Ministry of Environment and Energy, the Ministry of Economy, Industry and Commerce and the Ministry of Labor (Decree No. 39310- MH - MINAE - MEIC - MTSS). The facilitation team consisted of Beatriz Paniagua, Jessica Chavarría and Jimmy Venegas. It also had the support of representatives from quality infrastructure organizations such as: Dahianna Marín from the Costa Rican Metrology

Laboratory, Luis Rodríguez from the Ministry of Environment and Energy, Diego Cordero from the Costa Rican Technical Standards Institute, Seidy Alfaro from the Costa Rican Accreditation Entity, Rolando Marín from the Ministry of Economy, Industry and Commerce and Eugenio Villegas from the Ministry of Finance.

The national context is framed within a series of policies and actions that Costa Rica has been implementing to promote the use of sustainable materials. It is important to note that of the four countries involved (Nicaragua, Uruguay, Argentina and Costa Rica), only Costa Rica has been developing a project sustainability stra- tegy to ensure that the impacts are maintained over time.

OBJETIVE

Quality assurance of measurements to determine the biodegradability of chemical substances in cleaning products in Costa Rica.

JUSTIFICATION

The project arose from the need to have a quality infrastructure to ensure that the cleaning products on the Costa Rican market catalogued as "biodegradable" certainly meet the biodegradability characteristics required by scientific standards.

It is worth mentioning that Costa Rica did not have the necessary infrastructure to provide, through reliable and traceable measurements, certainty to consumers regarding the purchase of cleaning products labeled as "biodegradable".

In addition, at the time the project began, Type 1 environmental labeling certification had not been developed and the environmental impact on aquatic biodiversity was unknown, since these products are disposed of in bodies of water.

For this reason, the transition to responsible production and consumption was encouraged, as well as the promotion of the use of biodegradable cleaning products that preserve aquatic biodiversity.

REFLECTION QUESTIONS

The following questions were posed for the value chain approach and identification of the interactions and needs of the quality infrastructure services:

- How can we achieve a production and consumption system that guarantees sustainable growth over time?
- In the case of biodegradable cleaning products, is it possible to speak of a product life cycle?
- Are raw materials used on a recurring basis to generate less waste?
- What are the national efforts to be made to reduce the carbon footprint in the production of biodegradable cleaning supplies?

SOURCE: LACOMET, 2019.

Working sessions with the actors involved in the project.

- Is the development of programs that encourage the collection of packaging an effective mechanism for its utilization?

UNIT OF ANALYSIS

Biodegradable cleaning products.

DEVELOPMENT

In order to establish the value chain, the CALIDENA organization was defined under the name: "Sustainability in the use of biodegradable cleaning products". The purpose of this process was to integrate and systematize the value chain for the biodegradable cleaning products industry through the support of Costa Rica's quality infrastructure services.

During the process, an analysis of the national context was carried out to identify what standards existed in the area of biodegradability and what were the needs for updating or generating standards.

In addition, testing laboratories that had the infrastructure to carry out biodegradability tests were identified in order to promote the development of their biodegradability testing capabilities.

On the other hand, it was identified that there was no conformity assessment competence for the accreditation of laboratories with biodegradability services and work was done to promote accreditation for laboratories that have developed their biodegradability testing capabilities.

Based on the results of this analysis, a series of actions were implemented by the quality infrastructure to develop national capacities within the framework of the project and the country's needs.

Specifically, technical standards and environmental seals were generated to modify the production methods of high-consumption products (in this case, biodegradable cleaning products) with lower environmental impacts.

The intervention activities developed within the framework of the CALIDENA action plan were as follows:

In Metrology:

The Costa Rican Metrology Laboratory

(LCM) trained personnel, purchased equipment, produced candidates for reference materials, carried out interlaboratory comparisons, developed infrastructure to establish traceability through comparisons, metrological diagnostics, studied the conditions for establishing control processes for plastics, participated in the standardization committees promoted by INTECO and promoted closer ties with the business sector.

In Accreditation:
El Ente Costarricense de Acreditación (ECA) The Costa Rican Accreditation Body (ECA) promoted the liaison of conformity assessment bodies within CALIDENA, as well as the accreditation of biodegradability testing laboratories under the ISO 10707, ISO 9888 and ISO 9408 standards and the promotion of environmental labeling certification schemes.

In Standardization:
The Technical Standards Institute of Costa Rica (INTECO) approved the standards associated with biodegradability testing of water-soluble organic chemicals (ISO 10707, ISO 9888 and ISO 9408).

RESULTS

Once these activities were implemented, the following results were obtained:

In Metrology:

- Production of a candidate material for reference material in cleaning products.
- In 2020, the first regional interlaboratory comparison was carried out with a biodegradability test scope. In 2021, the second regional interlaboratory comparison was carried out with a biodegradability test scope.
- Within the framework of the subproject "Biodegradability: a path towards the responsible use of organic chemicals", we collaborated in the development of the "Guide for the estimation of uncertainty for biodegradable tests of water-soluble organic chemicals" (in Spanish and English).
- In 2021, the primary method for the calibration of dissolved oxygen sensors was developed and implemented.
- In 2021, we participated in the regional comparison for the calibration of dissolved oxygen sensors using the primary method implemented.
- The company participated in a commission with the Ministry of Finance, the Ministry of Health and the ICRC to promote the biodegradability of single-use plastics.

In Accreditation:
Testing laboratories have extended the scope of accreditation for the performance of biodegradability tests:

- Instituto Tecnológico de Costa Rica - Laboratory of the Chemical and Microbiological Research and Services Center - CEQIATEC.

Accredited Test: Cleaning Products and Cosmetics. PT-QU-30 Biodegradability (A02). LD and LC or working range (10-100) %, INTE/ISO 10707:2018 See scope at: **www.eca.or.cr**

- Environmental Analysis Laboratory National University. LAA-UNA.
  Accredited Test: Cleaning Products and Cosmetics. PT-QU-30 Biodegradability (A02). LD and LC or working range (10-100) %, INTE/ISO 10707:2018 See scope at: **www.eca.or.cr**

In addition, ECA expanded the scope of product certification in eco-labeling. It also participated in the process of establishing requirements for the "Environmental Seal of the Americas.

In Standardization:

We proceeded with the development and revision of INTE/ISO 10707:2018, INTE B13 "Environmental Labeling Type I. Environmental criteria for cleaning products for general use and cleaning products for kitchens and bathrooms. Am 1: 2018. Cleaning products", where improvements are made on the evidence required to demonstrate compliance with biodegradability.

In addition, method INTE/ISO 10707, Water quality. Evaluation in aqueous medium of the "final" aerobic biodegradability of organic compounds. Method by analysis of biochemical oxygen demand (test in closed vessels).

SUSTAINABLE PROCUREMENT PROCESS

We worked together with the Interministerial Purchasing Committee (MEIC-MINAE-Ministry of Finance) to promote the inclusion of the biodegradability requirement for cleaning products purchased at the government level through the Sustainable Public Purchasing Framework Agreement methodology.

Companies producing biodegradable cleaning products were encouraged to sell these products to the government. Training was provided on the interpretation of the biodegradability requirement in sustainable public procurement through the Institutional Environmental Management Program of the Ministry of the Environment and Energy (MINAE).

CONCLUSIONS

The CALIDENA project developed in Costa Rica is a success story, as it achieved the objective of identifying and developing the quality infrastructure services required to promote sustainability in the use of biodegradable cleaning products.

Activities were generated from a harmonized and coordinated process between quality infrastructure entities and industry. In addition, entities that have a direct impact on the establishment of environmental policies and the generation of demand for biodegradable cleaning products were involved.

The action plan was satisfactorily executed thanks to the commitment of all the parties involved, and products were produced that are still available to the population. This model can be replicated in other countries with the same needs, since it has been carried out under a systematized coordination and follow-up scheme.

LESSONS LEARNED

Promoting environmental protection: preserving water quality and aquatic life

Manufacturing companies can make life cycle commitments by establishing production programs that reduce their carbon footprint and implementing eco-design for maximum use of natural resources through:

- The use of solar energy for the entire energy consumption of the plant and offices
- Rainwater harvesting
- The provision of workspaces illuminated by natural sunshine

Use biodegradable cleaning products with improved environmental performance throughout the life cycle

Some techniques that can be implemented are:

- Increased use of raw materials from renewable sources
- New formulations with lower impact and higher performance
- Distribution of presentations concentrated in:
  - Reduction of water consumption during the process.
  - Prevention of the generation of plastic use in its packaging.
  - Emission reductions in transportation activities.

Maintaining the balance between progress and sustainability

Producers mitigate negative effects on the environment by using biodegradable products that are free of toxic contaminants or contamination of aquatic resources during use. In addition, the risk of product contamination can be reduced, for example, in the food industry.

Recurrent use of raw materials to reduce waste generation

Efforts to reduce the carbon footprint in the production of biodegradable cleaning products can include the use of plastic containers produced from recycled resins and the implementation of programs that encourage container collection, reuse and recycling as a final step.

QUALITY INFRASTRUCTURE

Maintain liaison and linkage with the productive sector to develop products for the chain and incorporate its immersion in the circular economy.

ABOUT THE CALIDENA APPROACH

The implementation of a follow-up committee to monitor the development of key actions related to product sustainability is vital for the success of the value chain.

It is recommended to maintain this methodology in order to be able to evaluate:

- Biodegradability in other products
- A strategy to follow on sustainable public procurement in the State
- New opportunities for other biodegradable products
- The development of a dissemination and communication strategy

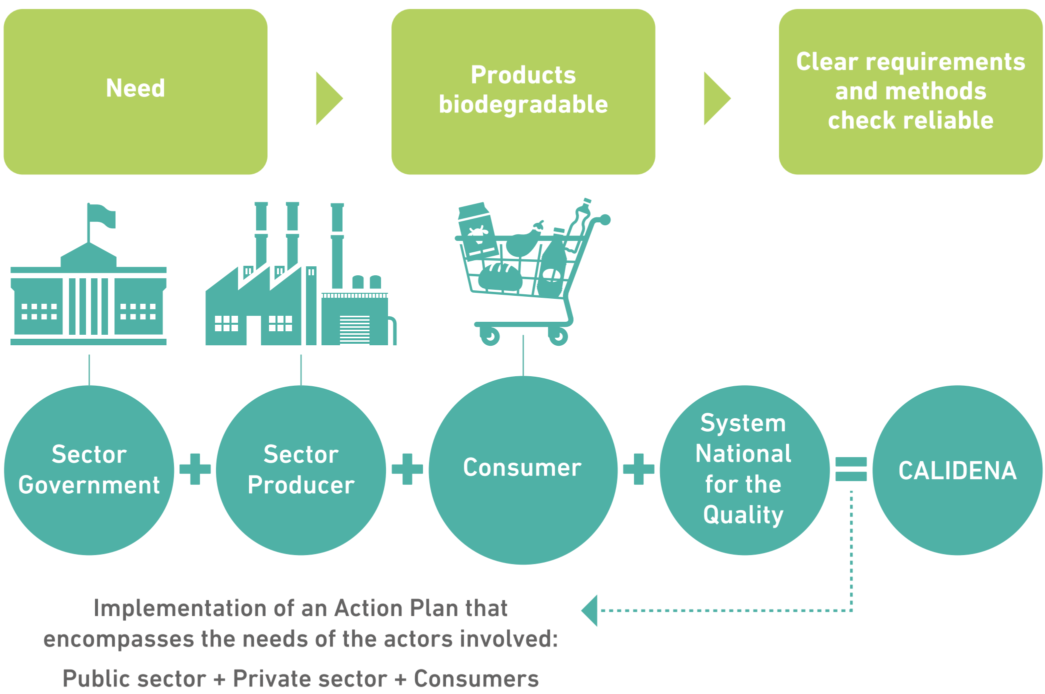
It is also important to strengthen the linkage and impact of the CALIDENA project with SDG 5 (Gender equality and women's empowerment), SDG 9 (Industry, innovation and infrastructure) and SDG 13 (Climate action) in related projects and initiatives.

FUTURE CHALLENGES

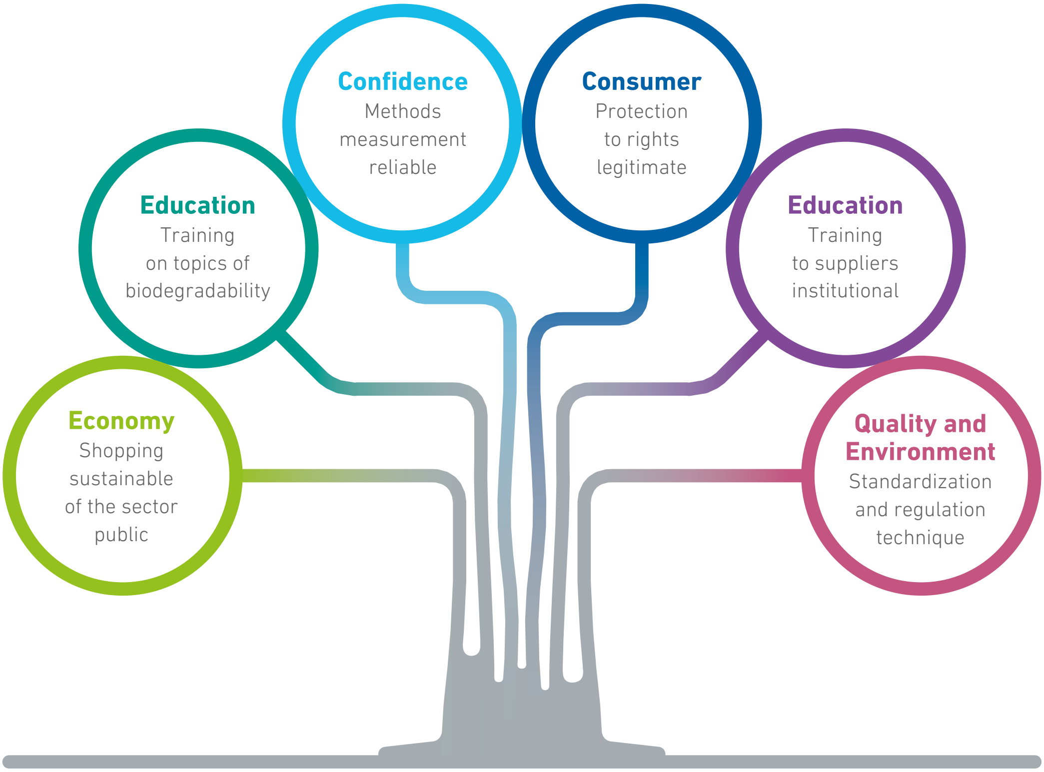
The participation of the State through the Ministries of Economy, Environment and Finance is relevant through the following actions:

- Insertion of MSMEs linked to biodegradable products in sustainable government procurement.
- Inclusion of the biodegradability requirement for cleaning products in the

How did the CALIDENA project come about?



Impacts of the CALIDENA methodology



framework of sustainable public procurement. This is to demonstrate, through biodegradability tests issued by ECA-accredited laboratories, that their products effectively meet the criteria and requirements for biodegradability.

- Training of suppliers on how to include and interpret the biodegradability requirement in sustainable public procurement posters on cleaning products.

Based on the results achieved, the Ministries of Economy, Environment and Finance are responsible for promoting sustainable public procurement at the national level, including biodegradability requirements in their framework agreements for cleaning products.

Likewise, they must train suppliers to include and interpret the biodegradability requirements that cleaning products must comply with. And promote the purchase of products and services that demonstrate a lower environmental impact -life cycle, eco-labeling certification, among others-. All of these are necessary areas of action in this process.

Executive Decree No. 39310- MH - MINAE - MEIC - MTSS National Policy for Sustainable Public Procurement and Creation of the National Steering Committee for Sustainable Procurement.

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Annex 3.

Validation of polymeric products marketed and promoted as biodegradable in Mexico (Stage 1)

Developed within the framework of the Chemical Metrology Project for traceability and standardization of the circular economy for plastics

GENERAL DATA

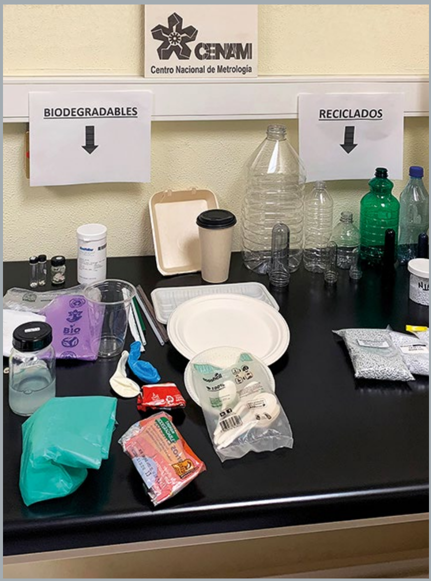
Country: México
Execution period: 2022 to date
Current status: under development

BACKGROUND

In the last five years, the circular economy in plastics in Mexico has become more relevant in the government and private sectors. The aim is to reduce the production of plastic waste by focusing on the use of single-use products and promoting the use of biodegradable materials and recycling by requiring a certain content of recycled material in the final products.

In conjunction with various governments, CENAM has worked on the international and national normative, regulatory and scientific analysis for the case of biodegradable polymeric products. Likewise, in the analysis and determination of the recycled polymer content in a finished product and the incidence of microplastics.

SOURCE: CENAM, 2022.



Identification of raw materials for polymeric products.

The focus of the project was on biodegradable materials, specifically compostable materials. In a first stage, CENAM, in coordination with some governmental entities, worked on the development of a protocol for the chemical characterization of finished polymeric products and polymeric raw materials that are presented as biodegradable in the Mexican market.

This was based on the applicable international standards for the identification of the polymers present, the determination of volatiles and the presence of regulated chemical elements.

The implementation of this characterization protocol has allowed the identification of the following types of products in the Mexican market:

- Biodegradable-compostable products with international certification.
- Products manufactured with biodegradable-compostable raw materials certified at international level and of recognized biodegradability in scientific literature.
- Products made from biodegradable -compostable raw materials (with or without certification) blended with polyethylene and flaunted as biodegradable.
- Products manufactured with biodegradable-compostable raw materials certified at international level and of recognized biodegradability in scientific literature.
- Products manufactured with conventional polymers (polyethylene, polypropylene) with oxo-degradant additives, ostensibly as biodegradable. This type of products have a high incidence in the country with the already known controversy due to the restrictions for their use in Europe.
- Conventional products - for example, polyethylene and polystyrene - arbitrarily labeled as biodegradable-compostable.

This situation, originated in the labeling, causes a potential incorrect handling of polymeric solid waste derived from this type of products.

In addition to causing concurrent environmental problems, it also provides incorrect information to the user of these products offered in the local market.

The next stage of the project involves the evaluation of the biodegradability, from a metrological perspective, of particular polymeric materials and mixtures, in disposal media with specific characteristics and controlled conditions -such as compost- that allow establishing the metrological traceability of these materials with respect to their biodegradation and ecotoxicity.

GENERAL OBJECTIVE

To carry out the chemical identification of the constituent polymers of the single-use products marketed in Mexico and presented as biodegradable-compostable within the framework of waste management and environmental impact.

SPECIFIC OBJECTIVES

- Determine the chemical nature of finished products marketed in Mexico and their relationship with the potential biodegradability-compostability of the product with respect to the applicable regulatory requirements.
- Identify metrological needs for verification, certification and validation of biodegradable-compostable materials considering technical and economic feasibility.

SOURCE: CENAM, 2022.

Direct analysis of carrier bags or single-use plastic bags in the FTIR-ATR Infrared Spectroscopy System.

JUSTIFICATION

In the last decade, various strategies have been designed and established at the international level to reduce and control the generation of plastic waste, now considered one of the main sources of contamination of soils, rivers and oceans. Therefore, in Mexico and other countries, the development, production and marketing of biodegradable-compostable products has been increasing.

In the last three years, several Mexican states and municipalities have established initiatives to regulate the marketing of single-use consumer products, such as carryout bags, containers, disposable food utensils and straws, thereby promoting the reduction of their use.

In view of this situation, the number of finished polymeric products that claim to be biodegradable has grown considerably in the Mexican market. This creates the need to verify them chemically, not only to ensure that they comply with the laws and regulations imposed, but also to have a traceable follow-up regarding waste management and the environmental impacts generated once they have completed their life cycle.

As a result of the work carried out by CE NAM with various governmental entities, several cases have been identified of products that are ostensibly biodegradable and that, in reality, are made of polyethylene with or without degrading additives.

For this reason, the present project identifies the problem and establishes the technical basis for the conformity assessment of finished plastic products marketed in Mexico and presented as biodegradable-compostable, with emphasis on the analysis of carrier bags or single-use plastic bags.

REFLECTION QUESTIONS

- Are the finished products offered as biodegradable-compostable really biodegradable?
- What effects can the incorrect identification of biodegradable-compostable products have on waste management and environmental impact?
- To what extent and how are the current measurement and conformity assessment needs of biodegradable-compostable polymeric inputs and outputs in Mexico being met?
- What are the challenges and/or perspectives in the short, medium and long term?
- What have you learned so far?

UNIT OF ANALYSIS

The project focuses on the needs of state entities for developing and/or complying with standards and regulations for regulating the production, marketing and distribution of biodegradable-compostable polymeric materials.

It is expected to su-pport the homogenization of these regulations and establish the basis for a future official Mexican standard.

The validation protocol for polymeric materials and finished products (single-use or carryout plastic bags), as well as its implementation, is carried out at the National Metrology Center.

It is supported by applicable international and national regulations, as well as scientific literature, guidelines, regulations and international laws.

CONCEPTUAL FRAMEWORK

Biodegradation (in plastics): biodegradation in plastics is the microbial conversion of all its organic constituents into carbon dioxide, new microbial biomass and mineral salts under aerobic conditions, or into carbon dioxide, methane, new microbial biomass and mineral salts under anaerobic conditions (SAPEA 2020).

Compostable plastic: plastic that undergoes degradation by a biological composting process to produce CO2, water, organic compounds and biomass, leaving no toxic, non-visible and distinguishable residues (ISO 17088:2012).

Bioplastic (bio-based polymer): material composed or derived, in whole or in part, from biological products derived from biomass, including plants, animals, marine and/or forest materials (SAPEA 2020).

Oxodegradable plastic: conventional plastic (PE, PP, PVC, etc.) in which pro-oxidant additives based on transition metals (Co, Mn, Fe, etc.) are incorporated that favor the fragmentation of the plastic as a result of its interaction with UV radiation or exposure to heat.

It is important to clarify that the inclusion of a pro-oxidant additive does not automatically convert a non-degradable plastic into a degradable or biodegradable one (European Commission, 2018).

Assessment of a biodegradable-compostable product: with regard to the assessment of biodegradability-compostability, international standards (ISO 18606 and EN 13432) recognize four general steps, each with its own acceptance criteria:

- Physicochemical characterization of the product
- Biodegradation
- Physical disintegration
- Ecotoxicity

According to international standards and certification bodies recognized worldwide, one of the most relevant and significant criteria for a product to be considered as biodegradable-compostable is that the ratio of chemical conversion of CO_2 produced with respect to the theoretical amount of CO_2 that would be produced by complete oxidation of the product is greater than or equal to 90 % (CO_2 /ThCO_2 ≥ 90 %) in a maximum time of 180 days in an industrial composting environment.

BIODEGRADABLE AND BIO-BASED PRODUCTS

Regarding the biodegradability of polymers and their chemical nature with respect to their fossil or bio-based origin, as shown in Figures 1(a) and 1(b), the fact that a polymer is bio-based does not necessarily imply that it is a biodegradable polymer. It is also necessary to point out the existence of biodegradable polymers of fossil origin, recognized worldwide. Therefore, the following should be clarified:

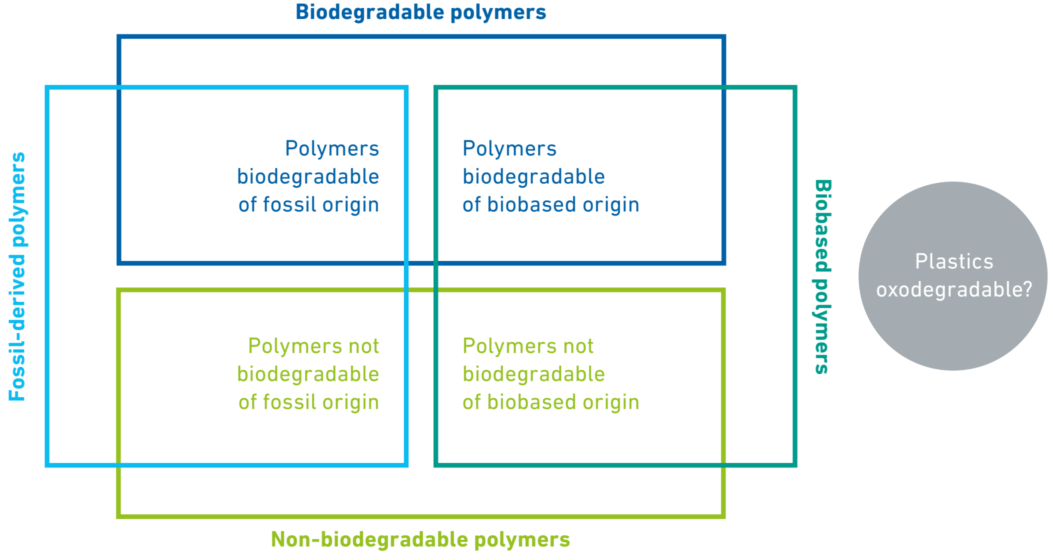
- “Not all bio-based plastics are biodegradable.”
- “Not all biodegradable plastics are bio-based.”

DEVELOPMENT

The project in its initial stage of research presents and analyzes as a basis one of the most commercialized polymeric products in Mexico and in the world, these being the carrier bags, in order to identify the constituent polymers, using infrared spectroscopy of a representative sample of carrier bags commercialized in an entity of the Mexican Republic where these bags are marketed as biodegradable or as biodegradable-compostable.

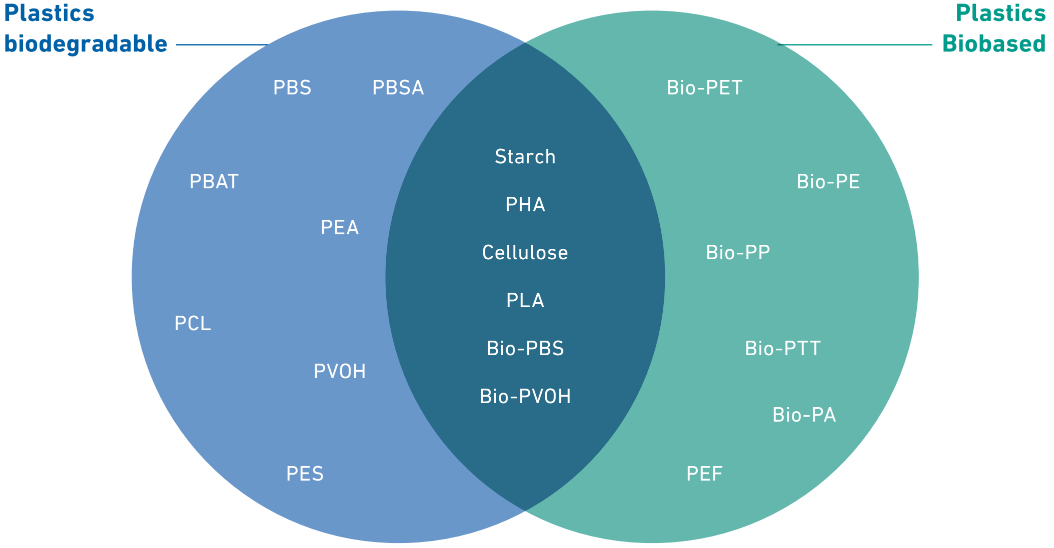
CENAM has several internal references that allow identification of the constituent polymers of the carrier bags examined by infrared spectroscopy as a representative example, as shown in Figure 2.

Figure 1a. **Classification of biodegradable and non-biodegradable polymers in terms of their origin**



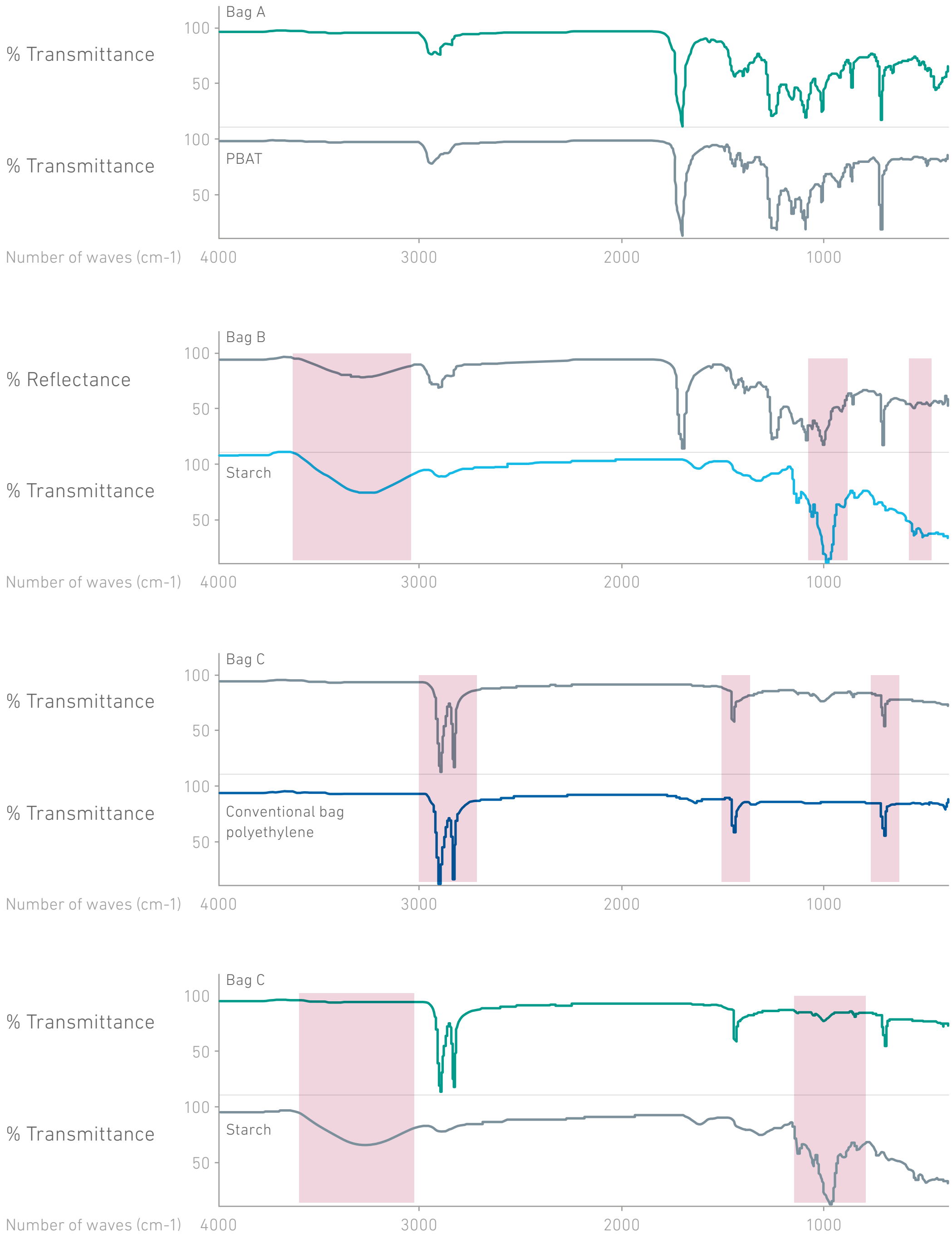
Source: Translated and adapted from SAPEA, Science Advice for Policy by European Academies. 2020. Biodegradability of plastics in the open environment. SAPEA. doi:10.26356/biodegradability plastics, Germany.

Figure 1b. **Main biodegradable and bio-based polymers at industrial level**



Source: Translated and Adapted from Hazell,J. 2017. Getting it right from the start Developing a circular economy for novel Materials.

Figure 2. Identification of polymeric compounds by infrared spectroscopy



Source: CENAM, 2022.

Table 1 shows the results of the infrared spectroscopy characterization of a total of 22 carrier bags, all of which are labeled as biodegradable or biodegradable-compostable. As can be seen, the great majority of the bags characterized are made of polyethylene (19 of them), one bag is made of polyethylene-starch and only two of them are made of polymers considered as potentially biodegradable-compostable, of which there are several reports and certificates from internationally recognized organizations of products composed of these polymers (PBAT-PLA and starch).

This analysis is a true reflection of many of the situations observed in Mexico, where products are being marketed ostensibly as biodegradable-compostable that, in reality, are still made of polyethylene and possibly with the addition of a pro-oxidant additive (oxodegradable products), which are also ostensibly biodegradable-compostable.

Added to this is the widely known controversy about their prohibition in the European Union and the fact that their biodegradable nature is not recognized by various sectors and environmental organizations.

One of the factors that most complicates the commercialization of biodegradable-compostable polymeric products is the fact that various governments require them to be certified by an internationally recognized body or by a nationally accredited body. Internationally, the cost of certification, including all the tests required, is estimated at approximately MXN $500,000, which represents a critical barrier for bag producers. In addition, Mexico does not have sufficient technical infrastructure to carry out such tests based on the demand that may exist.

In this sense, it is very important to consider the chemical and physical traceability of marketed products as a tool to develop more feasible technical and economic validation protocols as presented in ISO 18606.

Figure 3 shows a diagram of the production of carrier bags made from biodegradable-compostable raw materials (polymers).

As can be seen, the polymeric raw material of the carrier bags - in this case, pellets or films - has been subjected to the four stages of characterization or evaluation for the determination of its biodegradation in compost. It has complied with the requirements of each stage considering, in the case of polymeric film, a certain thickness. Given the fulfillment of all requirements, this raw material is eligible for certification.

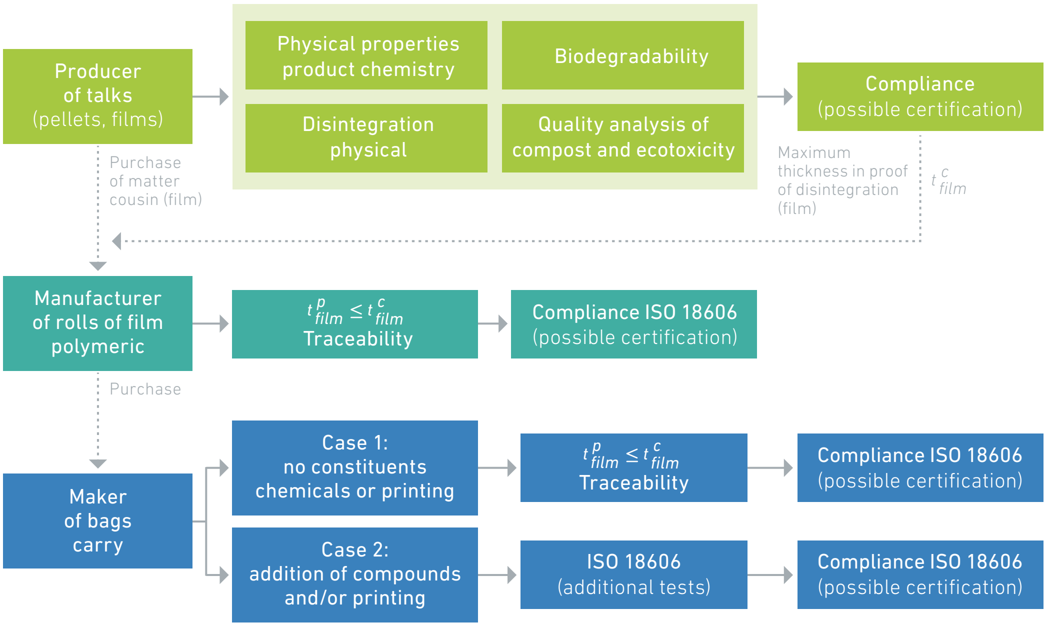
In the scenario of a subsequent commercialization of this raw material for a manufacturer of film rolls, or for the production of carrier bags, it is important to note that the imperative need to submit these products, intermediate or final, to the four stages of characterization for the

Table 1. **Polymers identified in the characterized carrier bags**

Bag No.	Identified polymers	Potentially biodegradable polymer(s)	Oxodegradable additive
1	Polyethylene	No	Yes
2	Polyethylene	No	Yes
3	Polyethylene	No	No
4	Polyethylene	No	Yes
5	Polyethylene	No	Yes
6	Polyethylene	No	Yes
7	Polyethylene	No	Yes
8	Polyethylene	No	Yes
9	Polyethylene	No	Yes
10	Polyethylene	No	Yes
11	PBAT, PLA and starch	Yes	No
12	PBAT, PLA and starch	Yes	No
13	Polyethylene	No	Yes
14	Polyethylene and starch	Only starch	No
15	Polyethylene	No	Yes
16	Polyethylene	No	No
17	Polyethylene	No	No
18	Polyethylene	No	No
19	Polyethylene	No	No
20	Polyethylene	No	Yes
21	Polyethylene	No	Yes
22	Polyethylene	No	Yes

Source: CENAM, 2022.

Figure 3. **Importance of physical-chemical traceability in the evaluation and certification of biodegradable-compostable products. Diagram based on ISO-18606**



Source: CENAM, 2022.

evaluation of biodegradable-compostable materials is no longer recognized. On the contrary, it recognizes traceability as an indispensable and necessary tool to evaluate and guarantee that the intermediate and/or final product is manufactured with the polymer resin previously evaluated and even certified.

In the case of carrier bags that present the addition of compounds or pigments different from those of the raw material initially evaluated, additional tests should be considered. In addition, those to evaluate chemical and physical traceability, such as physical disintegration and ecotoxicity tests, depending on the case.

Consequently, as can be seen, the first stage of evaluation of a biodegradable-compostable product or raw material is very important. Such characterization will allow the potential establishment of chemical and physical traceability in intermediate, final or derived products, with respect to those raw materials or products evaluated and/or certified in the first instance. This will be done by performing a series of characterization tests to identify constituent polymers, regulated chemical elements, volatile solids and film thickness. These tests will make it possible to establish the correspondence (traceability) between the certified polymeric product and the one being marketed.

CONCLUSIONS

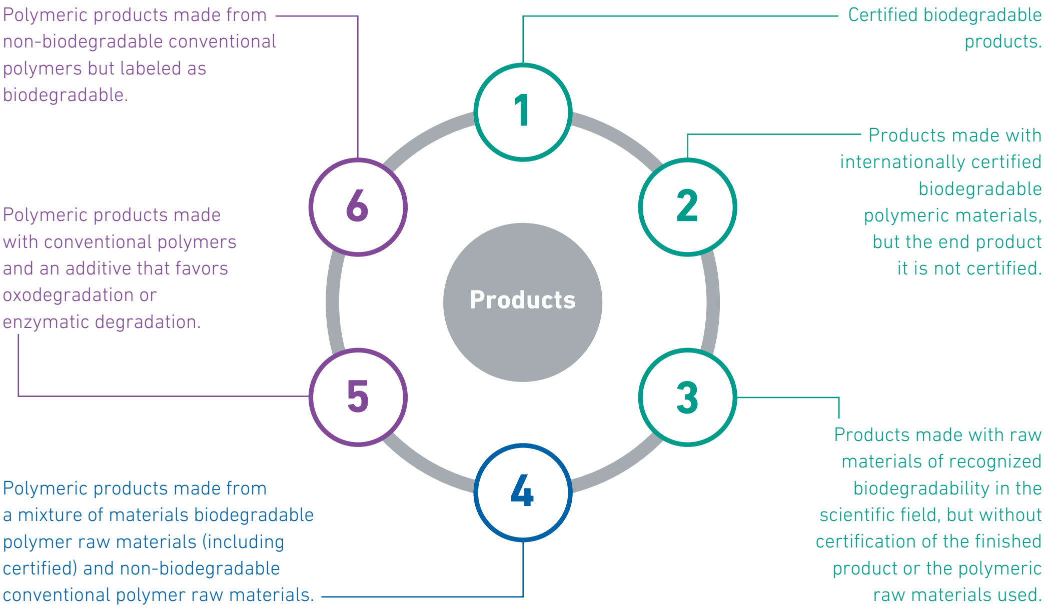
As a result of the case study and CENAM's work in recent years, it is possible to draw the following conclusions:

- Based on their chemical structure, six main types of single-use polymeric products, including carrier bags or shopping bags, have been identified (see Figure 4).

In the exercise carried out with a State of the Republic, and according to CENAM's experience, it has been possible to identify a high incidence of carrying bags labeled as biodegradable and/or biodegradable-compostable, which are made of polyethylene, which shows the use of misleading information to the consumer in addition to the impacts generated to the environment and public health.

The certification of each and every one of the types of biodegradable-compostable finished products, considering the four evaluation stages established in the applicable international standards, does not repre-

Figure 4. Types of marketed single-use polymeric products, in relation to their chemical structure



Source: CENAM, 2022.

sent the most viable path for its regulation in Mexico, given the technical and economic feasibility of carrying it out. In this sense, the chemical and physical traceability, recognized in ISO 18606, allows the development of more agile evaluation and certification protocols from the technical and economic fields for those finished products manufactured from polymer resins that are integrally evaluated and/or certified in biodegradability-compostability.

It is also very important to promote the development of complementary studies oriented to the integral evaluation of polymeric mixtures of commercial importance and the effect that different additives can have on biodegradation in compost. The establishment of the chemical and physical traceability of finished polymeric products marketed not only in Mexico, but also internationally, will be of great importance to evaluate the composition of these products, their behavior and the impacts produced on the environment.

It is recommended to consider the analysis and subsequent evaluation of polymeric products with pro-oxidant (oxodegradable), enzymatic additives and starch-polyethylene mixtures to define their biodegradability in different disposal media and to determine their environmental impacts.

LESSONS LEARNED

- There is a problem, to some degree systematic, in the labeling of single-use products in relation to their biodegradable-compostable character.
- It is important and critical to promote a verification program for products marketed in Mexico to identify the chemical characteristics of the products and proper waste management.
- No waste management program will be efficient if the characteristics of each type of single-use product marketed are not identified and recognized. To this end, it is essential to have clear and environmentally responsible labeling that allows for proper classification.
- The implementation of regulations and requirements for single-use products must also consider the accessibility of services involving testing and certification costs, among others, to which small and medium-sized companies can resort. On the other hand, there is the need to strengthen the local technical infrastructure to provide services with greater scope in view of the wide range of existing products, a need that is also shared in other countries of the region.
- Some manufacturers submit to CENAM, or to the respective authorities, products manufactured with polymeric raw materials or finished products certified in compostability in order to obtain authorization for their commercialization. However, they continue to market products made from non-biodegradable polymers such as polyethylene.
- The degree of interest, scope and implementation of the regulations in the

different states of the Mexican Republic is very diverse, which is why it is very important to harmonize criteria through an official Mexican standard that considers not only the technical parameters of international standards, but also provides strategies to confront the panorama of action with the different sectors of the country.

- It is necessary to have a massive public awareness and dissemination program that invites consumers to question the reliability of labels and products and that mainly continues to promote the reduction of the consumption of single-use products.

RECOMMENDATIONS

- Promote a program to verify plastic products claimed to be biodegradable-compostable in order to determine their chemical nature and analyze their final disposal.
- Strengthen government programs to help reduce the consumption of single-use plastic products.
- Promote the regulation of the labeling of single-use products with respect to their biodegradable-compostable nature.
- To develop material validation protocols focused on chemical and physical traceability, not only of polymeric products made with biodegradable-compostable resins, but also considering polymeric products with pro-oxidant (oxodegradable) additives, enzymatic additives and starch-polyethylene mixtures. The objective is to establish their degradation potential in different disposal media and to determine their adverse effects on the environment.

For more information:

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For review:

ISO 18606: 2013. Packaging and the environment - Organic recycling

EN 13432:2000. Packaging- Requirements for packaging recoverable through composting and biodegradation- Test scheme and evaluation criteria for the final acceptance packaging

ISO 17088:2012. Specifications for compostable plastics

BS 8472:2011. Methods for the assessment of the oxo-biodegradation of plastics and of the phyto-toxicity of the residues in controlled laboratory conditions

Annex 4.

Detail of quality infrastructure projects linked to sustainability issues with scope of action in Latin America and the Caribbean and supported by the Physikalisch-Technische Bundesanstalt - PTB

Country or region	Project name	Execution period	Implementation partners
Bolivia	Strengthening quality infrastructure for renewable energy and energy efficiency	2019 - 2023	IBMETRO
Bolivia	Program for the promotion of quality infrastructure that supports drinking water and wastewater measurements and testing II	2020 - 2023	IBMETRO
Brazil	Strengthening quality infrastructure for renewable energy and energy efficiency II	2021 - 2023	Inmetro
CARIFORUM	Technical barriers to trade component	2019 - 2024	CROSQ, INDOCAL
Ecuador	Strengthening quality infrastructure for energy efficiency	2019 - 2023	MPCEIP, INEN, SAE
Guatemala	Strengthening the quality infrastructure for environmental and climate protection	2021 - 2023	SNC - National Quality System
The Caribbean	Strengthening quality infrastructure for sustainable energy in the Caribbean	2019 - 2023	CARICOM Regional Organization for Standardization and Metrology (CARICOM) Quality (CROSQ) and the Dominican Institute for Quality (INDOCAL)
Colombia	Development of the competencies of the National Quality Subsystem (SICAL) and its stakeholders (ARTICAL II)	2020 - 2024	INM, ICONTEC, ONAC, SIC, ANDI, ASOCEC

Country or region	Project name	Execution period	Implementation partners
Colombia	Quality for competitiveness: Reducing quality gaps in micro, small and medium-sized enterprises in Colombian regions	2019 - 2021	INM, INCONTEC
Latin America and the Caribbean	Regional fund for quality infrastructure for biodiversity and climate protection in Latin America and the Caribbean	2014 - 2022	IAAC, COPANT, SIM + various institutions of quality infrastructure in Latin America and the Caribbean
Latin America and the Caribbean	Strengthening Quality Infrastructure for the Circular Economy in Latin America and the Caribbean (QI4CE LAC)	2020 - 2023	IAAC, COPANT, SIM + various institutions of quality infrastructure in Latin America and the Caribbean
Mercosur	Strengthening quality infrastructure for the promotion of energy efficiency in MERCOSUR member countries	2019 - 2022	CI institutions coordinated by the SGT N°3 (Sub-Working Group of the Mercosur for Regulation and Conformity Assessment)
Mexico	Strengthening quality infrastructure for renewable energy and energy efficiency	2018 - 2021	Institutions of the CI in Mexico, Dominican Republic and Cuba
Nicaragua	Improving quality assurance services in the water sector	2019 - 2023	National Quality System (NQS)
Peru	Strengthening of the national quality infrastructure to support natural resource management and monitoring of environmental and climate parameters in Peru	2022 - 2025	INACAL

Source: Physikalisch-Technische Bundesanstalt – PTB, 2022.

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