Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
National Metrology Institute

INTERNATIONAL COOPERATION

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

german cooperation
DEUTSCHE ZUSAMMENARBEIT

On behalf of

Federal Ministry
for Economic Cooperation
and Development

On behalf of the Federal Government of Germany, the Physikalisch-Technische Bundesanstalt promotes the improvement of the framework conditions for economic, social and environmentally friendly action and thus supports the development of quality infrastructure.

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Abstract

This study explores the contribution of quality infrastructure (QI) to the development of a green economy (GE) using the example of the countries of Latin America and the Caribbean (LAC). It is part of the project *Promotion of innovation in the green economy by including quality infrastructure*, which the Physikalisch-Technische Bundesanstalt (PTB) implemented on behalf of the Federal Ministry for Economic Cooperation and Development (BMZ) from December 2015 to July 2019. Project partners were the regional organizations of the quality infrastructure in Latin America and the Caribbean (COPANT, IAAC and SIM).

In the introduction (Chapter 1), the authors explain the project context and point out the importance of a green transformation for Latin America and the Caribbean.

The fundamental concepts of the study are *green economy, quality infrastructure and innovation*. In chapter 2, the authors explain each term or pair of terms individually and their relationships.

The *green economy* aims to improve human wellbeing and social equity while significantly reducing environmental risks and ecological scarcities. A green economy is a low carbon, resource-efficient and socially inclusive system of trade and industry. Green economy encompasses urgent issues beyond climate change, such as clean water, sustainable fishing practices, and soil erosion. Nevertheless, critiques mention that the green economy concept is committed to growth thinking and stands in the way of the necessary transformation of lifestyles.

The term *innovation* refers to implementing a technical or organizational novelty in the market or society and not just an invention or discovery. Market failures often hamper innovation. In addition, green innovations address environmental externalities and affect individual societies or global communities (e. g. in the case of overfishing and contamination of the oceans). Public support for green innovations is, therefore, essential.

The *quality infrastructure* is *...the system comprising the organizations (public and private) together with the policies, relevant legal and regulatory framework, and practices needed to support and enhance the quality, safety and environmental soundness of goods, services and processes.*

The quality infrastructure is required for the effective operation of domestic markets, and its international recognition is essential to enable access to foreign markets. It is a critical element in promoting and sustaining economic development and environmental and social wellbeing. Quality infrastructure relies on metrology, standardization, accreditation, conformity assessment, and market surveillance. [1]

The authors describe quality infrastructure services as part of a broader green economy innovation system and, therefore, an integral part of green technologies. In this context, quality infrastructure contributes to innovation in the green economy by creating new or improving existing services. Quality infrastructure fosters green innovations at different levels:

- Development of new quality infrastructure services, corresponding to the needs of the green economy;
- Redesign of products and services of the green economy by including the offer of QI;
- Innovations in relevant processes, standards and regulations.

The third chapter of the study identifies possible contributions of the quality infrastructure in selected industries prioritized stakeholders and quality infrastructure representatives.

1 *https://www.inetqi.net/documentation/quality-infrastructure-definition/* (retrieved July 8, 2021)

The authors of the study examine:

- Global value chains (GVCs) and sustainability standards
- Sustainable tourism
- Waste management, recycling and closed-loop recycling management
- Smart cities
- Clean production (CP)
- Green building

The authors assume that standards contribute to triggering and accelerating green innovation and the diffusion of green technologies through different impact chains, e.g., by preparing or complementing smart regulation (mandatory) or encouraging consumer behaviour changes (voluntary). In all cases, standards conformity assessment structures to be effective levers for change. Therefore, this part of the study aimed to define entry points for quality infrastructure services to support a green economy development.

The first chapters (1, 2 and 3) were written at the beginning of the project, while chapter 4 summarises the project's actual results. Pilot initiatives explored possible contributions of quality infrastructure for innovation in the green economy. The Project Advisory Committee approved the following six pilot interventions under three headings:

- Waste management
  - Management of hazardous waste in laboratories
  - Quality in the value chain for e-waste
- Ecological footprint
  - Product category rules
  - Water footprint
- Environmental monitoring
  - Cost-effective air quality measuring instruments
  - Proficiency test on air quality

In each pilot, quality infrastructure and the green economy representatives from different countries worked together. Experts brought additional knowledge to the cooperation context. Each pilot aimed to identify the specific needs of the green economy for quality infrastructure services and to make them available in a manageable format.

The authors refer to the evaluators who attest to the project a high relevance in the concluding chapter. The relevance is shown by the great interest of the project partners in strengthening their capacities in proficiency tests, forums and technical support. These offers of the project enabled them to get closer to the actors of the green economy, to identify demand, and develop better or new services for the green economy. The pilot interventions served as good examples and contributed to the improvement of quality infrastructure and its green economy related services. The project helped introduce the green economy and the concept of sustainable development into quality infrastructure institutions and facilitate institutional change.

The authors conclude with recommendations on advancing the dialogue between the different communities promoting a more sustainable economic model and the representatives of the quality infrastructure institutions in Latin America and the Caribbean region. The vision is that green transformation will, in the long run, affect all economic areas, and quality infrastructure services will become an integral part of a green economic system.

1. Introduction

This study explores the contribution of quality infrastructure (QI) to the development of a green economy (GE) using the example of the countries of Latin America and the Caribbean (LAC).

Latin America and the Caribbean region is of particular importance for the topic for several reasons. Most countries have reached Middle Income Country (MIC) status, are urbanizing fast and have a growing middle class. The pressure on national resources (including sink capacities) is high and will grow further soon. Examples of successful decoupling between economic growth and depletion of natural resources (see below) can provide valuable lessons for countries with low-income country (LIC) status but are catching up.

The authors prepared the first version as a baseline study for the project *Promotion of innovation in the green economy by including quality infrastructure* commissioned by the German Federal Ministry of Economic Cooperation and Development (BMZ) and implemented by the International Cooperation Department of the Physikalisch-Technische Bundesanstalt (PTB).

The project aimed to improve conditions for the green economy (GE) in Latin America and the Caribbean by using new and enhanced services of the quality infrastructure. These include, for instance, product certifications based on standards for social and environmental criteria or measurement and testing services for monitoring systems to identify the environmental impacts of products and services. The focus was on three fields of intervention:

1. Assessing the needs for quality infrastructure services and promoting communication and cooperation,
2. developing quality assurance services for the green economy, and
3. testing quality assurance services for the green economy.

The implementation partners were the Inter-American Metrology System (SIM), the Pan American Standards Commission (COPANT) and the Inter-American Accreditation Cooperation (IAAC), which support the development of and the cooperation among the metrology and standardization institutes as well as the national accreditation bodies. Furthermore, all three regional organizations are members of a formalized regional network, the Quality Infrastructure Council of the Americas (QICA). Additional partners in the project were regional and international organizations like the United Nations Environment Programme (UN Environment) and the Organization of American States (OAS). All partners were committed to promoting National Innovation Systems, quality infrastructure or a green economy in Latin America and the Caribbean.

The project operated – with an extension – for three years and eight months (December 2015 to July 2019) and was evaluated in 2019.

In 2020, PTB decided to publish this updated version of the study after the project. However, the research is still relevant because it systematically explains the basis for the work of the quality infrastructure institutions in the field of the green economy.

In the first part (chapter 2), the authors explain the terms quality infrastructure, Innovation and green economy, the concepts behind them and their connections. With readers working in quality infrastructure institutions in mind, we begin by summarizing the genesis and conceptual background of the *green economy* and highlight its somewhat controversial reception in Latin America and the Caribbean. The concepts of *innovation* and *innovation systems* are then introduced. The explanations of *quality infrastructure* should help readers from a business, green economic or policy background understand the basics of this system, which ensures the quality of products and processes. This section concludes with a chapter discussing the interlinkages of the three concepts, which should be new for readers from varying backgrounds.

After laying the theoretical groundwork, the second part (chapter 3) outlines the importance of quality infrastructure for innovation in selected green economic sectors. Inspired by the results of five mini-workshops held in 2016 in Bolivia, Argentina, Mexico, Costa Rica and Colombia, this study analyses the (potential) role of innovations and quality infrastructure in six sectors that are highly relevant for the economies of Latin America and assessed as important by PTB's Green Economy Team, namely:

- Global value chains (GVCs) and sustainability standards
- Sustainable tourism
- Waste management, recycling and circular economy
- Smart cities
- Green building
- Cleaner production

To make the complexity manageable, in some of the topical fields (for instance, GVCs and CP), examples of particular relevance for Latin America and the Caribbean region will be presented. However, the overall hypothesis is that standards help trigger and accelerate green innovations and the diffusion of green technologies through different impact chains, e. g. preparing or complementing smart regulations (compulsory standards) or fostering changes in consumer behaviour (voluntary standards). In all cases, standards must be accompanied by a conformity assessment to be effective levers for change.

In the third chapter, we describe pilot experiences of the project implementation. We present six pilot experiences in three sectors:

- Waste management (the hazardous waste in laboratories and e-waste)
- Ecological footprint (product category rules and water footprint)
- Environmental monitoring in cities (intercomparison between environmental laboratories and the introduction of low-cost sensors for measuring atmospheric air pollution)

In the final chapter, the authors evaluate the experiences and give recommendations for a further commitment of the quality infrastructure to promote the green economy. The study concludes with the message that transformation to a green economy is an opportunity for the national quality infrastructure in Latin America and the Caribbean Region. At the same time, the countries need quality infrastructure services to make this transformation work and help to create consumer confidence in green products and production systems.

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2. Key Concepts

The starting points for this study are three concepts: *green economy, innovation and quality infrastructure*. Figure 1 shows the structure of this chapter:

1. Each of the three (3) vertices refers to one key concept (see chapters 2.1, 2.2, 2.3)
2. Each of the three (3) arrows refer to the relation between two concepts (2.4), and the overall relationship of concepts and relations (2.5).

Triangle of Key Terms

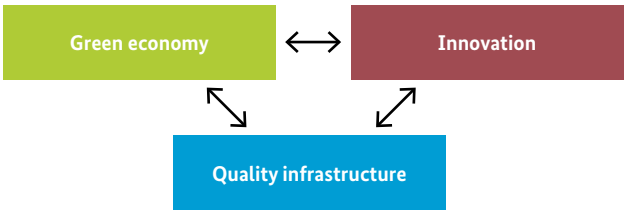

Figure 1: Triangle of Key Terms. Source: Own elaboration.

2.1. Green Economy in Latin America and the Caribbean

2.1.1. Definition and Genesis

The green economy (GE) is one of several concepts used to define a more sustainable approach to production and development. The United Nations Environment Programme (UN Environment) defines a *green economy* as: *...one that results in improved human well-being and social equity while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive.* (UNEP, 2011, 2).

UN Environment formulated this concept to question two hypotheses (Schmitz and Becker, 2013):

1. that economic development and ecological sustainability are incompatible and
2. that only countries that are already rich can afford the luxury of an ecologically sustainable economy.

Higher global growth can instead be achieved through green investment rather than a business-as-usual strategy (UNEP, 2015).

The concept of a green economy evolved within the debate on sustainable development.[2] In 1992, the United Nations Conference on Environment and Development (UNCED), known as the Rio Conference or Earth Summit, raised global public awareness of integrating environment and development. The Earth Summit influenced subsequent UN conferences, including Rio+20, and helped set the global green agenda, resulting in:

- the United Nations Framework Convention on Climate Change (UNFCCC) – a climate-change agreement that led to the Kyoto Protocol and the Agenda 21,
- the United Nations Convention on Biological Diversity (CBD) and
- the United Nations Convention to Combat Desertification (UNCCD).

The Earth Summit also created new international institutions, such as the Commission on Sustainable Development (CSD) and led to the reform of the Global Environment Facility (GEF).

2 A key publication was the *Blueprint for a Green Economy* (Pearce 1989) commissioned by the UK Department of Environment to assist them in formulating a policy response to 1987 World Commission on Environment and Development *(the Brundtland Commission)*. The *Pearce Report* was updated and republished as BARBIER, E. B. & MARKANDYA, A. 2013. *A new blueprint for a green economy, Routledge.*

The United Nations Conference on Sustainable Development (UNCSD), also known as Rio+20, was the third international conference on sustainable development aimed at reconciling the economic and environmental goals of the global community and focused on two main themes:

- How to build a green economy to achieve sustainable development and lift people out of poverty, including support for developing countries.
- How to improve international coordination for sustainable development by building an institutional framework.

The immediate result was the nonbinding document *The Future We Want*, in which 192 governments renewed their commitment to sustainable development. It included the concept of green economy in the context of sustainable development and poverty eradication.

The Rio+20 outcome document also supported the development of the Sustainable Development Goals (SDGs). In 2015, countries adopted a set of goals to end poverty, protect the planet, and ensure prosperity for all as part of a new sustainable development agenda (the 2030 Agenda). UN member states will be expected to use these SDGs to frame their future agendas and political policies over the next 15 years. Most of the 17 SDGs are directly or indirectly related to the green economy.

The definition of green economy refers to *low carbon*. This relates to international efforts on climate change following the agreements of the United Nations Climate Change Conference in Paris. The critical result was an agreement to limit global warming to 1.5 °C, which will require zero net emissions sometime between 2030 and 2050 (Rogelj et al., 2015).

Figure 2: Sustainable Development Goals. Source: UN (*http://www.un.org/sustainabledevelopment/sustainable-development-goals/* (Retrieved on 06/04/2020).

2.1.2. The Scientific Debate about Limits of Growth and Decoupling

The idea that our planet has limits has been present in policy and academic discussions since the publication of *The Limits to Growth* (Meadows et al., 1972). The book presented a model in which five variables: world population, industrialisation, pollution, food production, and resource depletion are growing exponentially, while the ability of technology to increase resource availability is only linear.[3]

Today, environmental scientists led by Johan Rockström from the Stockholm Resilience Centre and Will Steffen from the Australian National University influence the debate with their concept of *Planetary boundaries*. In 2009, the group proposed a framework designed to define a *safe operating space for humanity* as a precondition for sustainable development. It is based on research showing that human actions have become the primary driver of global environmental change since the Industrial Revolution. The scientists assert that once specific tipping points, or *planetary boundaries*, are passed, there is a risk of irreversible and abrupt environmental change (Rockström et al., 2009). They identified nine Earth system processes with boundaries that mark the safe zone for the planet.

However, due to human activities, some of these have already been crossed, while others are in imminent danger.

3 The book received a lot of criticism, but new research has confirmed that its predictions were correct. However, it did not pay sufficient attention to technologies or stabilization behaviors of policies that are now key to understanding and mitigating global pollution and climate change Turner, G. M. (2008). *A comparison of The Limits to Growth with 30 years of reality.* Global Environmental Change 18 (3): 397-411.

Planetary Boundaries

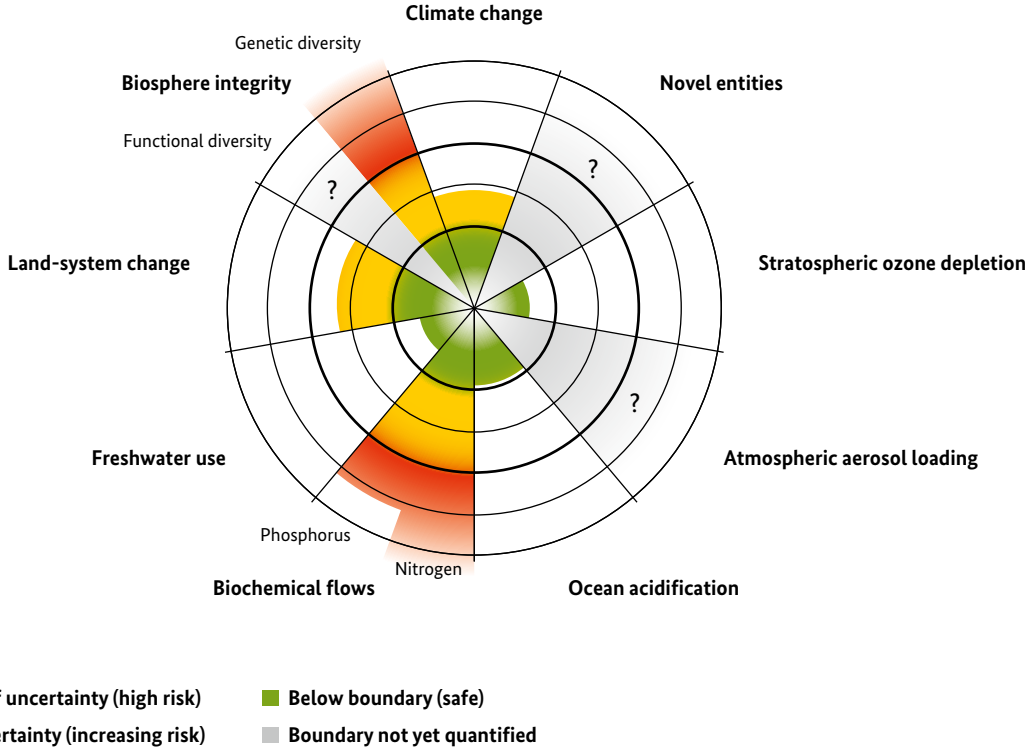

Figure 3: Planetary Boundaries. Source: Rockström et al. 2009, Steffen et. al. 2015.

This framework was updated by STEFFEN, W., RICHARDSON, K., ROCKSTRÖM, J., CORNELL, S. E., FETZER, I., BENNETT, E. M., BIGGS, R., CARPENTER, S.R., DE VRIES, W. & DE WIT, C.A. 2015. Planetary boundaries: Guiding human development on a changing planet. Science, 347 6223 1259855.

A reasonable response to this challenge is the concept of *decoupling*, which refers to the ability of an economy to grow without corresponding increases in environmental pressure. Decoupling, then, refers to increased resource productivity, where economic growth remains higher than resource use and depletion (*doing more with less*).

In 2011, the International Resource Panel, hosted by UN Environment, warned that by 2050, the human race could triple its consumption of minerals, ores, fossil fuels and biomass unless nations start decoupling economic growth rates from the rate of natural resource consumption.

In 2014, a second report, *Decoupling 2* (von Weizsäcker et al., 2014), highlighted technological opportunities for developing and developed countries to accelerate decoupling and reap the environmental and economic benefits of increased resource productivity.

Nevertheless, Tim Jackson (Jackson, 2009) stresses the importance of differentiating between relative and absolute decoupling when using the term:

- Relative decoupling refers to a decline in the resource and emission intensity per unit of economic output. Resource impacts fall relative to GDP, which may still be rising.
- Absolute decoupling refers to a situation where resource impacts decline in absolute terms. Resource efficiencies must increase at least as fast as economic output.

Jackson cautions against technology optimists using the term decoupling as an *escape route from the dilemma of growth* (Jackson, 2009), stating that *there is quite a lot of evidence to support the existence of [relative decoupling]* in global economies, however *evidence for [absolute decoupling] is harder to find* (Jackson, 2009).[4]

4 It is important to acknowledge the rebound effect which means the reduction in expected gains from new technologies that increase the efficiency of resource use, because of behavioural or other systemic responses, see VIVANCO, D.F., KEMP, R. & VAN DER VOET, E. 2016. How to deal with the rebound effect? A policy-oriented approach. *Energy Policy*, 94, 114-125.

Two Aspects of Decoupling

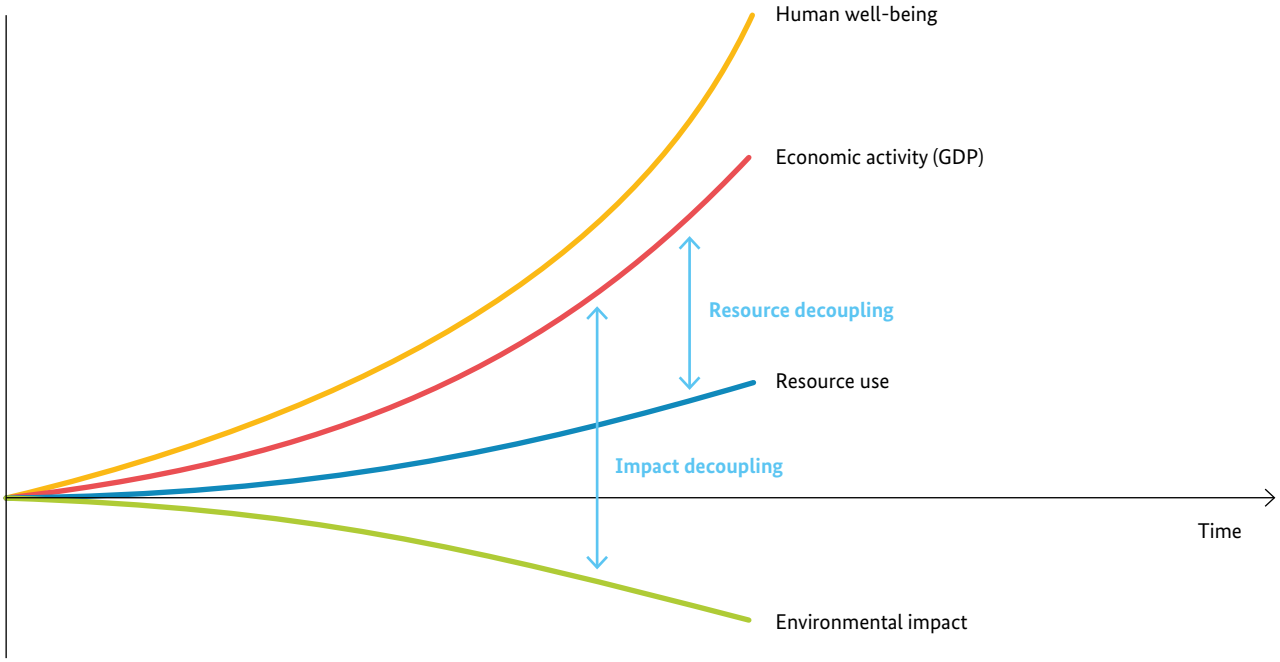

Figure 4: Two Aspects of Decoupling. Source: Von Weizsäcker, de Larderel et al. 2014

2.1.3. Promoters of a Green Economy

The green economy – and other related issues development – tops the global agenda. International organisations are involved in many green economy programs and initiatives, such as the *Partnership for Action on Green Economy* (PAGE)[5], The *Green Growth Knowledge Platform* (GGKP)[6] and *The Global Environment Facility* (GEF)[7]:

Other relevant organisations with activities in Latin America and the Caribbean are:

- The World Resource Institute (WRI)[8], a global research organisation is spanning over 50 countries, with offices in Brazil, China, Europe, India, Indonesia, and the United States.
- The World Resource Forum (WRF)[9] is an independent non-profit organisation that connects and fosters knowledge exchange on resources management among business leaders, policymakers, NGOs, scientists, and the public.

2.1.4. Green Economy in Latin America and the Caribbean – Critique and Specificities

Green economy emphasises the market and the internalisation of externalities as critical instruments for overcoming humanity's environmental challenges. The concept has thus received a lot of criticism from growth and market sceptical groups (Unmüßig et al., 2016, Kenis and Lievens, 2015) and developing countries, particularly in Latin America (Pengue, 2012), which follow alternative development concepts. Their main critiques are:

- The green economy neglects political power, interests, and conflicts by regarding green transformations as a mainly technological challenge.
- Green economy advocates that market failures cause environmental problems, which need to be remediated by more markets.
- The mantra of green economy is to put a price tag on carbon emissions and resource use. Unfortunately, this ignores the complexity of the problem and does not help decarbonise the economy.
- The green economy advocates technological innovation without seeing the need for fundamental changes in lifestyles (e.g. public and private transport systems).
- Green economy follows the idea of resource efficiency, which ignores the fundamental limits to growth.

These critiques are also applicable to related concepts like green growth, green industry, green value chains or the circular economy (see Annex 2). All are inspired by the idea of sustainable development, defined in the Brundtland Report as *the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.*[10] All seek to make development strategy more feasible but differ in the relative importance of economic, social and environmental concerns and the focus on the present versus the future.

Nevertheless, there is broad agreement in research, policy and society that the challenge of green transformation is global, but the specific needs for change vary between continents and countries. This is a technical but also a political and ideological challenge. For example, Latin America and the Caribbean have long debated structural inequality, the dependence of the countries of the South on the North and the appropriation of nature (Fundación Bariloche, 1976, Herrera, 2004 Acosta and Martínez, 2009).

Today we see increasing sensitivity to sustainability in Latin America and the Caribbean due to the impacts of climate change and the socio-environmental conflicts associated with mining, deforestation and water availability in the region (Pengue, 2012). Many countries are particularly vulnerable to climate change, especially the Small Island Developing States in the Caribbean (SIDS) (Kelman, 2014).

5 *www.un-page.org* (Retrieved on 06/04/2020)

6 *www.greengrowthknowledge.org* (Retrieved on 06/04/2020)

7 *www.thegef.org* (Retrieved on 06/04/2020)

8 *www.wri.org* (Retrieved on 06/04/2020)

9 *www.wrforum.org* (Retrieved on 06/04/2020)

10 *http://www.un-documents.net/ocf-ov.htm*, Paragraph 27 (Retrieved 20/04/2020)

At the current stage of this research, we highlight the following specific features in Latin America and the Caribbean:

- Latin America and the Caribbean is rich in natural resources and biodiversity, features an export surplus of natural resources and, thus, experiences overexploitation of natural resources (Acosta, 2011).
- Latin America and the Caribbean is still the world's most unequal region[11], and its economic growth remains low.[12]
- Latin America and the Caribbean is one of the most urbanised regions in the world (UN-Habitat, 2012).
- In the past decade, the middle class in Latin America grew 50 % and now represents 30 % of the population (Ferreira et al., 2012, 1).
- Specific progress in green technologies can be observed on the continent.[13]

2.2. Innovation

2.2.1. Terminology and Concepts

The term *innovation* refers to implementing a technical or organizational novelty in the market (or society)[14] and not solely an invention or discovery. Several types of innovation can be observed in the economic process (Schumpeter, 1934).

- introduction of a new product[15],
- implementation of a new production method,
- access to new sources of supply,
- exploitation of new markets and
- new ways to organize a business.

Schumpeter's idea of innovation as a *process of creative destruction* is that entrepreneurs are continuously recombining existing resources and are driven by creative destruction, which triggers structural change and development (Schumpeter, 1942).

Three types of innovations can be identified, according to their degree of novelty (OECD, 2005):

- innovation can be new to the firm,
- new to a specific market or
- new to the world.

Innovations usually occur in a systemic context. The concept of National Innovation Systems (NIS) describes an innovative process as a flow of technology and information among people, enterprises and institutions at the national level. According to this theory, innovation and technology development result from a complex set of relationships among enterprises, universities and government research institutes (Lundvall, 1992, Nelson, 1993, Freeman, 1995).[16]

11 *https://www.weforum.org/agenda/2016/01/inequality-is-getting-worse-in-latin-america-here-s-how-to-fix-it/* (Retrieved 20/04/2020)

12 *http://www.imf.org/external/pubs/ft/survey/so/2015/CAR042915A.htm* (Retrieved 20/04/2020)

13 Potts, Lynch et al. 2014 identify Latin America as a *global leader* in application of sustainability standards

14 In the recent debate, the concept of innovations is broadened to include *social innovations* , see e. g. POL, E. & VILLE, S. 2009. Social innovation: buzz word or enduring term? *The Journal of Socio-Economics*, 38, 878-885.

15 We must add "…and services" given that the service economy is now also predominant in Latin America and the Caribbean and has the greatest potential for innovation, see ABOAL, D., ARIAS-ORTIZ, E., CRESPI, G., GARDA, P., RASTELETTI, A., RUBALCAVA, L., VAIRO, M. & VARGAS, F. 2015. La innovación y la nueva economía de servicios en América Latina y el Caribe: Retos e implicaciones de política. *In:* INTERAMERICAN DEVELOMENT BANK, I. (ed.). Washington DC.

16 There is a huge overlap between NIS and National Quality Infrastructure (see chapter 2.3). Metrology Institutes, Standardization Bodies and Laboratories, etc. are thus essential parts of the NIS.

2.2.2. Innovating in the Developing World

Innovation differs at varying stages of development. In advanced countries, enterprises often innovate by pushing the knowledge frontier through technological innovation, research and development (R&D). Meanwhile, in developing countries, firms learn to master, adapt and improve existing technologies (UNCTAD, 2007). Increasing the capacity to absorb foreign technology is critical in low and middle-income countries that have exploited low-wage comparative advantages rather than strengthened domestic competencies (The World Bank, 2008). To catch up with high-income countries, they need to accelerate growth and significantly expand indigenous R&D.

Developing countries, like those in Latin America and the Caribbean, face specific challenges in this regard (Altenburg, 2010):

- The sectoral composition of developing economies is less diversified, which limits the possibilities of cross-sectoral fertilization.[17]
- Low and medium-tech industries (LMT) like textiles, food processing and mining are vital in Latin America and the Caribbean region[18] and thus crucial for promoting innovation.
- The private sector engages less in innovation, particularly *new to the world* and *new to the market* types.
- Informality is a widespread and increasing phenomenon.
- Formal rules and laws are less well developed and not properly enforced. Thus, the innovation systems in Latin America and the Caribbean focus more on non-market-institutions and risk losing the benefits derived from the innovative dynamics of the market system.
- Governments are usually less effective and less accountable. This creates difficulties in promoting and fostering competitive advantages.
- Innovation policies are prone to political capture and mainly implemented to benefit the relevant bureaucracies.

Consequently, Latin America and the Caribbean countries traditionally suffer from an innovation and technology gap.

2.3. Quality Infrastructure

2.3.1. Definition and Components

This term *quality infrastructure* was agreed upon in 2017 by the International Organizations for Metrology (BIPM and OIML), Standards (ISO) and Accreditation (IAF and ILAC), UNIDO, UNECE and The World Bank within the framework of the INETQI cooperation network. Quality infrastructure is therefore defined as:

The system comprising the organizations (public and private) together with the policies, relevant legal and regulatory framework, and practices needed to support and enhance the quality, safety and environmental soundness of goods, services and processes.

The quality infrastructure is required for the effective operation of domestic markets, and its international recognition is important to enable access to foreign markets. It is a critical element in promoting and sustaining economic development, as well as environmental and social well-being.

It relies on metrology, standardization, accreditation, conformity assessment, and market surveillance (in regulated areas).[19]

A simplified model identifies five main interrelated components of a quality infrastructure (see figure below):

1. Metrology
2. Standardization
3. Testing & inspection
4. Certification and
5. Accreditation

17 Related research is that on *economic complexity* as a driver for prosperity, see HIDALGO, C. A. & HAUSMANN, R. 2009. The building blocks of economic complexity. *Proceedings of the National Academy of Sciences*, 106, 10570-10575.

18 For the conceptual grounding see VON TUNZELMANN, N. & ACHA, V. 2005. Innovation in 'low-tech' industries. *The Oxford handbook of innovation*, 5, 13.

19 *https://www.bipm.org/utils/common/pdf/QI-definition.pdf*

National Quality System

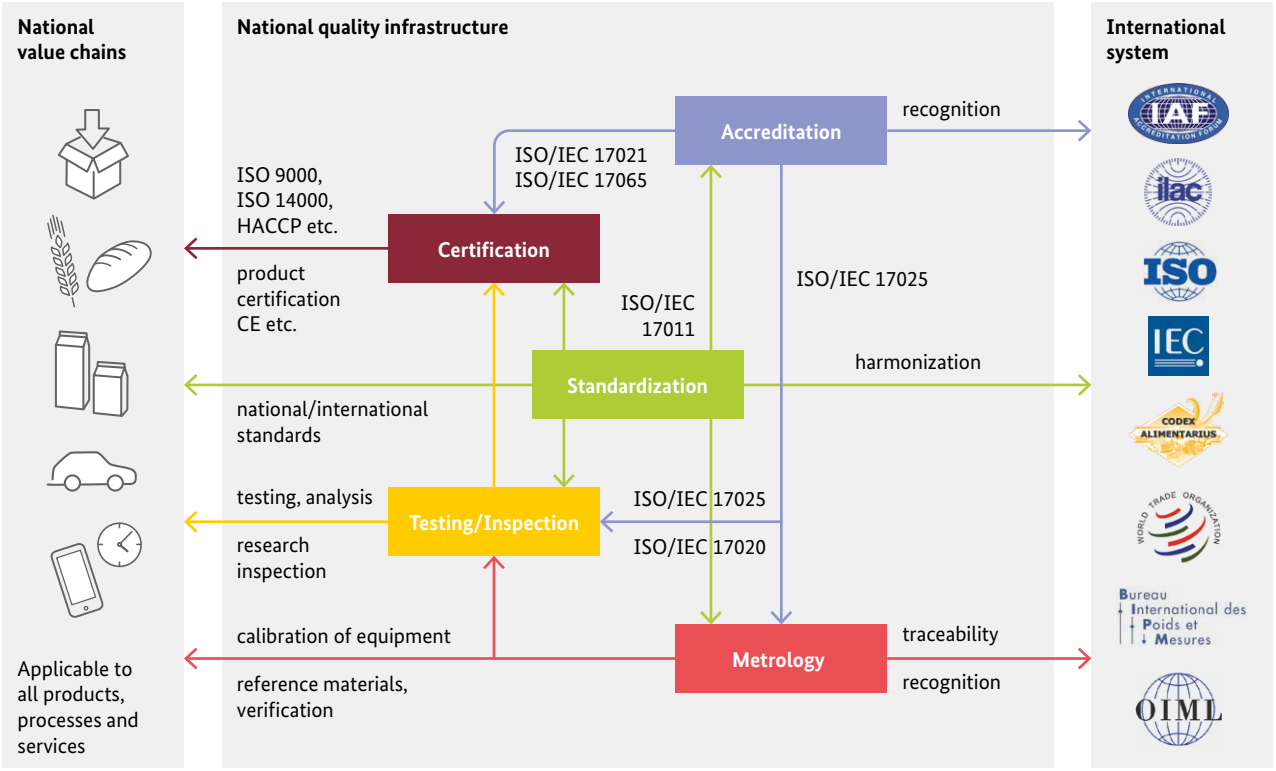

Figure 5: National Quality System. Source: PTB.

2.3.2. Metrology

The International Bureau of Weights and Measures (BIPM) defines metrology as *the science of measurement, embracing both experimental and theoretical determinations at any level of uncertainty in any field of science and technology.* [20]

A vast field, it can be divided into three overlapping activities:

- Definition of internationally accepted units of measurement
- Realization of these units of measurement in practice
- Application of chains of traceability linking measures to reference standards [21]

Metrology also has three (3) essential subfields:

1. *Scientific metrology* is responsible for the definition and quantity of the units of measurement, the development of new measurement methods, the realization of measurement standards, and the transfer of traceability from these standards to users in society. In addition, the BIPM maintains a database of the metrological calibration and measurement capabilities of various institutes around the world.

2. *Industrial metrology* concerns the application of measurement science to manufacturing and other processes, ensuring the suitability of measurement instruments, calibration, and quality control of measurements. Although the emphasis in this area is on the measures themselves, the traceability of the calibration of measurement devices is necessary to ensure confidence in those measurements.

20 *http://www.bipm.org/en/worldwide-metrology/* (Retrieved 20/04/2020)

21 *http://www.bipm.org/en/worldwide-metrology/* (Retrieved 20/04/2020)

3. *Legal metrology* refers to statutory requirements and involves units of measurement, measuring instruments and methods of measurement performed by competent bodies. Such statutory requirements arise from, amongst others, the need to protect the health, public safety, the environment, enabling taxation, protection of consumers and fair trade.

A core concept in metrology is *traceability*, which refers to the *property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty* (BiPM et al., 2008). Metrological traceability permits the comparison of measurements results anywhere in the world.

2.3.3. Standards

A standard is defined as a *document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose.*[22] As the connectors between the (national) quality infrastructure system components, standards ensure that products and services are safe, reliable, and of good quality. For businesses, they are strategic tools that reduce costs by minimizing waste and errors and increasing productivity. In addition, they help companies to access new markets, level the playing field for developing countries and facilitate free and fair global trade.

There are several different types of standards which can be explained as follows:

- *Voluntary standards and technical regulations:* Technical requirements that a supplier has to meet, which can be demanded by public authorities (mandatory) or based on a private agreement between trade partners (voluntary). In the World Trade Organization (Agreement on Technical Barriers of Trade, TBT), the written mandatory requirements are called *technical regulations*. At the same time, the second type is referred to as *standards*.

  Technical regulations define minimum requirements to protect the *legitimate objective* (health, security, safety, and environment) of consumers, while standards define additional requirements for quality.[23]

- *Public and private standards:* Within the WTO TBT agreement, there is a Code of Good Practice for the preparation, adoption and application of standards. These are elaborated with the participation of all interested parties by the International Standard Organization (ISO)[24] and its regional[25] and national member organizations. In addition, there are also private standards developed by private companies and associations (Potts et al., 2014). This group also includes sustainability standards. The challenge is to make both standard systems compatible, balance the cost-benefit ratio and generate trust in the whole system (ISO, 2011).

- *Product and process standards:* There has been a shift from verifying the individual product to inspecting the whole production and management system process. The latter reduces the need for frequent product inspection and plant visits, which in turn reduces costs. In addition, public authority controls have changed from product inspection to controlling whether appropriate systems are in place and function correctly.

22 *www.iso.org/iso/home/standards.htm*

23 Information on Technical barriers to trade: *https://www.wto.org/english/tratop_e/tbt_e/tbt_info_e.htm*

24 Additionally, there are specific ISO for electric and electronic (IEC) and telecommunication (ITU)

25 COPANT is the regional standard organization in Latin America and the Caribbean, and unlike in other world regions COPANT has decided not to elaborate own standards for Latin America and the Caribbean. COPANT mainly promotes the adoption of international ISO and IEC standards by its member states.

2.3.4. Conformity Assessment

Based on standards, the (national) quality infrastructure institutions provide conformity assessment services (CAS) to companies and consumers. These can be provided by either the manufacturer (first-party), the purchaser (second party), or a third-party organization that is independent of both the supplier and purchaser, which is, in most cases, the best option.

There are five (5) specific CAS:

1. *Testing* is a technical operation to determine one or more characteristics according to a procedure. Testing can be done in-house or by external laboratories.

2. *Certification* is a statement by a third party that products or services comply with the requirements of a standard. The certificate can also be used for labelling schemes to highlight specific attributes of a product.

3. *Inspection* includes many other forms of conformity assessment but is distinguished by the degree of subjectivity and judgement. *Is this article fit for purpose? Is it safe?* are questions that may require both objective data (test results) and the judgement of a knowledgeable and experienced inspector.

2.3.5. International Framework

International organizations represent the main components of the (national) quality infrastructure with institutions at the regional and sub-regional levels.

Since 2014, the Latin America and the Caribbean [26] region has had the *Quality Infrastructure Council of the Americas*.[27] This organization aims to foster competitiveness, innovation, trade and consumer safety by helping OAS member states to access internationally recognized quality infrastructure services.

26 The CARICOM member states have their own subregional quality infrastructure organization in CROSQ

27 The Council was created by the three regional technical organizations SIM, COPANT and IAAC and endorsed by the Ministers and High Authorities of Science and Technology of OAS. It is recognized by the OAS Science Technology Committee which founded several working groups, one of them addressing quality infrastructure; this is coordinated by Canada and Panama, supported by several countries and with participation of SIM, COPANT and IAAC.

International Quality Infrastructure Organizations Relevant for LAC

Area	International	Regional
Metrology	International Bureau of Weights and Measures (BIPM) International Organization of Legal Metrology (OIML)	Interamerican Metrology System SIM
Standards	International Standards Organization (ISO)/ International Electrotechnical Commission (IEC) ITU	Pan American Standards Commission, COPANT*
Accreditation	International Accreditation Forum (IAF) International Laboratory Accreditation Cooperation (ILAC)	Inter-American Accreditation Cooperation (IAAC)

Table 1: International Quality Infrastructure Organizations Relevant for LAC. Source: Own elaboration.

* Standardization organizations at sub-regional level are CROSQ for CARICOM and ANM for Mercosur

2.4. Interrelation of Three Key Concepts

2.4.1. Green Innovation = Green Economy + Innovation

Transforming the economy for a sustainable future requires innovation. Therefore, innovation and technology play a vital role in increasing well-being without overloading the earth's capabilities (Stamm et al., 2009).

In his analysis of innovation diffusion, Schumpeter emphasized the tendency of innovation to *cluster* in specific industries and periods, resulting in business cycles and *long waves* in the world economy (Fagerberg, 2005).

From the steam engine to the internet, for the last 200 years, the economy has gone through five long waves.

While in the previous Kondratieff cycle the information, age led to a tremendous increase in labour productivity, the key to a strong and sustainable economy in the next long cycle seems to lie in an increase in the productivity of resources and energy. Growth will probably continue to be generated from a new mix of economics, ecology and social commitment. This recent structural change in the economy has been termed *Eco-Trends* (Naumer, Nacken et al. 2010).[28]

28 Similar RIFKIN, J. 2016. How the Third Industrial Revolution Will Create a Green Economy. *New Perspectives Quarterly*, 33, 6–10.

Kondratieff Cycles – Long Waves of Prosperity

Rolling 10-year yield on the S&P 500 since 1814 till March 2009 (in %, p.a.)

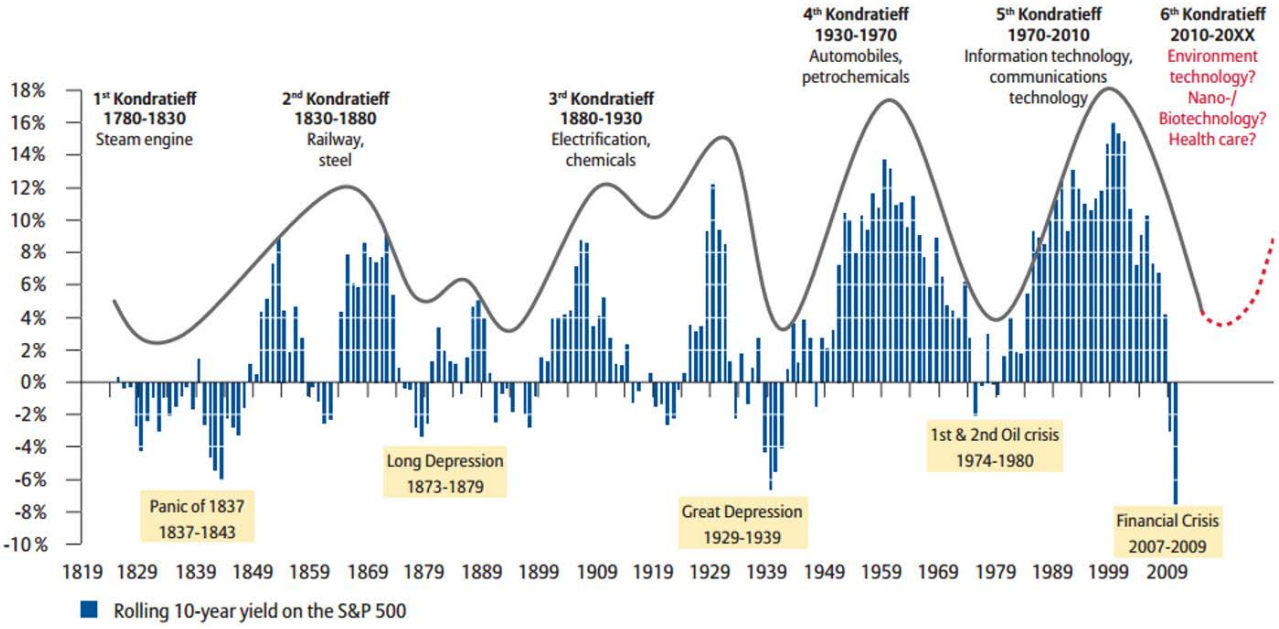

Figure 6: Kondratieff Cycles – Long Waves of Prosperity. Source: Naumer, Nacken et al. 2010, 6.

The transformation to a green economy already shows different magnitudes of green innovations:

Green Innovation Typology

Innovation type	Definition	Examples
Incremental	Modifying and improving existing technologies or processes to raise the efficiency of resource and energy use without fundamentally changing the underlying core technologies	Clean production
Disruptive	Changes how things are done or specific technological functions are fulfilled without necessarily changing the underlying technological regime itself	Change from incandescent to fluorescent lighting Transition from fossil to biofuels Sustainability labels
Radical	A full-scale shift in the technological regime of an economy, which can lead to fundamental changes in the economy's enabling technologies (*game changer*)	Change from a fossil to a renewable energy-based system

Table 2: Green Innovation Typology. Source: Own elaboration based on OECD 2011.

But it is not only explicitly *green innovations* that are important. Cross-cutting technologies (nanotechnology, biochemistry) maybe even more relevant (OECD 2011).

Decoupling will be only possible if green technologies [29] grow faster than resource and energy consumption. There are different ways for countries to phase in green technologies:

1. Carbon pricing is probably most widely promoted. But the formal mechanisms of carbon offsetting require slow-moving international (and national) agreements and are challenging to implement in developing countries. It also requires high levels of technical capacity to develop, monitor and assess such projects.

2. Another way to disseminate green technologies in developing countries is *standards*. [30]

In Latin America and the Caribbean, there are a few companies that develop or implement at the frontier of green innovation (an exception is bio-fuel-innovation in Brazil [31]), most of the company's focus on technology diffusion where novelty is introduced in a local context.

2.4.2. Innovation and Quality Infrastructure

Quality infrastructure services support entrepreneurs in developing new products or making their production processes more efficient. They can be seen as a specific form of knowledge-intensive business services (KIBS) that individual enterprises could not afford on their own (Cunningham, 2009).

At the same time, conformity assessment by an independent organization helps increase trust between sellers and buyers in simple and complex value chains. Quality infrastructure also helps avoid barriers to the division of labour due to technical incompatibilities.

29 We use a broad definition of technologies in the sense of *know how* including Social Tech and Physical, see Nelson, R. R. (2003). Physical and social technologies and their evolution, Économie appliquée 56 (3): 13–32.

30 A well-documented example is the use of voluntary and mandatory standards to promote energy-efficient household appliances in India (Chaudhary, Sagar et al. 2012).

31 In the area of biofuels Brazil was able to create an innovation system that generates *new to the world* innovations building upon adaptations and improvements on a well-known, simple technology. Dantas, E. (2011). *The evolution of the knowledge accumulation function in the formation of the Brazilian biofuels innovation system.* International Journal of Technology and Globalisation 5 (3–4): 327–340.

On the other hand, the use of quality infrastructure services is usually not free and increases transaction costs, which can hinder innovation. (Environmental) quality requirements can also be seen by the supplier – especially an SME – as an obstacle to trade. If the supplier is induced to adapt products and processes to higher levels of sustainability, this might trigger sustainable innovation. However, if it shifts trade patterns to less demanding customers or markets, this effect will not be achieved (Harmes-Liedtke, 2010).

Metrology supports innovation in different ways:

- The availability of cost-effective measurement services is critical for trade and competitiveness. Innovations in metrology reduce transaction costs and help integrate products and processes.
- National measurement systems based on standards are platforms for innovation.
- In emerging countries, it can contribute to the development of new technologies (part of *excellence* or world-class metrology) or play a role in disseminating basic measurement knowledge and calibration services throughout the economy (*inclusive metrology*).

The positive effects of standards are (Swann, 2010):

- First, standardization helps build focus, cohesion and critical mass in the emerging stages of technologies and markets.
- Standards for measurements and tests help innovative companies demonstrate to the customer that their innovative products possess the features they claim to have and that the levels of risks for health, safety, and the environment are acceptable.
- Standards codify and disseminate state-of-the-art and best practices.
- Open standardization processes and standards enable competition between and within technologies and thus contribute to innovation-led growth.

Types of Standards and their Effects on Innovation

	Positive Effects on Innovation	**Negative Effects on Innovation**
Compatibility / Interoperability	■ Network externalities ■ Avoiding lock-in old technologies ■ Increasing variety of system products ■ Efficiency in supply chains	■ Monopoly power ■ Lock in in old technologies in case of strong network externalities
Minimum Quality / Safety	■ Avoiding adverse selection ■ Creating trust ■ Reducing transaction costs	■ Raising rival's costs
Variety Reduction	■ Economies of scale ■ Critical mass in emerging technologies and industries	■ Reducing choice ■ Market concentration ■ Premature selection of technologies
Information	■ Providing codified knowledge	

Table 3: Types of Standards and their Effects on Innovation. Source: Blind 2013: 10.

Conformity Assessment can also contribute to innovation:

- Calibration services can help to increase resource efficiency and reduce waste. Correctly calibrated equipment reduces measurement uncertainty and helps to minimize inputs, costs and waste, e.g. recycling or disposal of non-compliant products.

- The services of testing labs can verify if a supplier meets buyer requirements and provide important feedback for the firm's internal learning process.

- Certification of a product or process can be costly and entail extensive reorganization. But this should be seen as an investment, which can reduce operational costs and improve company processes. It is also usually an entry requirement for more lucrative markets.

Finally, accreditation help businesses to make informed decisions when procuring conformity assessment and related services. Accreditation helps the government by supporting evidence-based policymaking in relation to accreditation and conformity assessment (Frenz and Lambert, 2014, Frenz and Lambert, 2012). A study on accreditation in Australia indicates positive impacts on efficiency, building new knowledge and process innovation (Agarwal et al., 2017).

2.4.3. Quality Infrastructure and Green Economy

To develop a green economy, Latin America needs an efficient and internationally recognized quality infrastructure. This enables developers, producers and retailers to increase the quality of green economy products and services. Quality assurance allows them to develop innovative solutions.

The potential of the quality infrastructure to support the green economy is not being fully exploited in the region. Most Latin America and the Caribbean countries lack internationally recognized quality infrastructure services for the green economy. The quality infrastructure institutions have not carried out a targeted analysis of the green economy's needs. In addition, the stakeholders of the green economy and the quality infrastructure do not maintain continuous relations and do not exchange experiences. Existing green economy initiatives and stakeholders do not take quality aspects sufficiently into account, and they lack the necessary knowledge of this subject and its possible benefits for green policy. Important potential for innovation thus remains unexploited, leaving stakeholders of the green economy at a competitive disadvantage in trade relations.[32]

Given the new paradigm of a sustainable or green economy, quality infrastructure needs to respond to these new challenges. Many of the traditional instruments and procedures follow the logic of standardization and verification and are immediately applicable for promoting more resource-efficient production. There is a clear need and opportunity to innovate.

The following table summarizes some examples where the components of quality infrastructure already contribute to the greening of the economy. Together they form an articulated synergic system.

32 This paragraph is a paraphrased from the project proposal and based on PTB experts experience

Relevance of Quality Infrastructure Components for Greening the Economy

QI component	Relevance for green economy (examples)
Metrology	■ Reliable measurement is required to make complex systems work (i. e. smart grids) ■ New technologies like green nanotechnology[33] require more precise measurements ■ Calibration of measurement equipment is required to make the work of sensors and other measurement instruments trustworthy
Standards	■ Standards help to codify green economic development ■ Standards are needed to integrate different components of green technologies ■ Standards help to scale up green solutions
Testing	■ Assessing conformity with sustainability standards requires reliable tests ■ Tests inform about problems and help improve processes within a sustainable quality management system
Certification	■ Eco-labels and sustainability certifications help consumers make informed decisions and choose green products ■ Sustainability certifications create competitive advantages for green businesses
Accreditation	■ The accreditation of laboratories and certification bodies confirm their technical competence and generate trust within the buyer and consumer community regarding test results and certifications. This can stimulate the consumption of validated and certified green products and services

Table 4: Relevance of Quality Infrastructure Components for Greening the Economy. Source: Own elaboration.

It is important to recognize that quality infrastructure emerged in the context of industrial mass production and is not necessarily designed to support (bio)diversity or acknowledge the limits of economic growth. However, its origin and embeddedness in industrial manufacturing make quality infrastructure prone to efficiency, which is particularly necessary for the resource-efficient production required by the GE.

Quality infrastructure contributes to a green economy in several ways:

- Guarantees interoperability (*plug and play*) of different components of complex technology platforms (i. e. renewable energy systems, green building or smart cities)
- Supports the dissemination of new technologies and increases consumer confidence
- Helps buyers and consumers to differentiate between sustainable and other products – non-environmentally friendly products could otherwise have a natural advantage because their suppliers do not invest in improving their environmental impacts
- Helps new, more environmentally friendly products reach new markets (see, i. e., Quinoa and Sacha Inchi[34] meeting European novel food regulation)
- Contributes to the development of general-purpose technologies, such as biotechnology, nano- and information communication technology which are vital for a greener economy

Challenges, especially for smaller developing countries, are to establish their own quality infrastructure in a competitive global context.

33 About Green Nanotechnology see e. g., IAVICOLI, I., LESO, V., RICCIARDI, W., HODSON, L.L. & HOOVER, M.D. 2014. Opportunities and challenges of nanotechnology in the Green Economy. Environmental Health, 13 78.

In Latin America and the Caribbean, nanotechnology is still in its infancy, but there are increasing activities to promote it in the region (for an overview see FOLADORI, G. & INVERNIZZI, N. 2013. Inequality gaps in nanotechnology development in Latin America. Journal of Arts and Humanities, 2 3 35. and for European and Latin American Cooperation for Nanotechnology Success, see *http://euronanoforum2015.eu/wp-content/uploads/2015/06/11_EuropeLatinAmericaCooperationNanotechnology-success_LicethRebolledo_10062015-v2-00000002.pdf*).

The NMI of Costa Rica organized for the 2016 metrology day a seminar on nano-metrology, see *http://www.lacomet.go.cr/index.php/centro-de-informacion/noticias-recientes/130-metrologia-quimica-y-nanometrologia*.

34 Sacha inchi, also known as the Inca peanut, is the seed of a plant that originates from the highlands of Peru. The seeds are commonly used as food both cooked and fried. It is sometimes assumed to be an upcoming *superfood*.

Disadvantages of developing countries are:

- Difficulties in reaching critical mass, especially in smaller countries
- High fixed costs
- Lead buyer based in industrialized countries
- Lack of quality culture

But: For developing countries, it is not feasible to live without quality infrastructure:

- Local quality infrastructure helps to reduce transactions costs, especially for SMEs
- Necessary vehicle for developing appropriate technologies (adapted to local conditions and specificities)

In general, quality infrastructure helps to participate in technology development.

2.5. Integration of Three Key Concepts – The Ways Forward

The idea of a green economy represents a specific market-driven means to achieve development within the planet's environmental limits. Given the particular reality of Latin America and the Caribbean region, it is vital to apply the concept in a flexible and context-sensitive way.

A green economy needs to help decouple economic growth from resource use and greenhouse gas emissions. Latin America and the Caribbean countries need to grow but not at the expense of their natural resources. Their economies depend on their natural resources because they are mainly centred on agriculture and mining. Finding sustainable ways of growing is challenging but, if possible, will have a very positive impact. It is also important to look beyond low carbon development because of the social inequality and disadvantages these countries face, in addition to climate vulnerability.

The social dimension of green development has special relevance in the region, as expressed by Latin American protagonists in shaping the SDG 2030 Agenda (CEPAL, 2016). The transformation to a green economy only seems feasible if it helps overcome disparities and seeks the well-being of all population groups – especially the middle class and the poor.

Both the organizations that promote the green economy and the institutions of quality infrastructure in Latin America and the Caribbean countries still have limited knowledge about the mutual relevance for the achievement of their own goals:

- Promoters of green economy must understand that quality infrastructure services are essential for the technologies needed for transformation to a green economy. If Latin America and the Caribbean countries cannot provide them, green innovation will be hindered by high transaction costs or lack of access to quality infrastructure services.

- For the representatives of quality infrastructure bodies, the green economy offers an excellent opportunity to expand their services. From the Latin America and the Caribbean perspective, it is also important that international standards are adapted to local conditions and disseminated to the whole economy. Many existing quality infrastructure services can be expanded to new clients and the relative costs reduced.

Quality infrastructure services should be seen as a part of a broader green economy innovation system and therefore an integral part of *green technologies*.

Quality infrastructure can contribute to innovation in the green economy in two ways:

1. Creating a new service or
2. Improving an existing service, i.e. applying a current quality infrastructure service to the field of GE

Green quality infrastructure innovations are fostered at different levels:

- Development of new quality infrastructure services, corresponding to the needs of the green economy
- Redesign of products and services of the green economy by including the offer of quality infrastructure
- Innovations in relevant processes, standards and regulations

3. Sector Studies about the Role of Quality Infrastructure for Greening the Economy

3.1. Selection of Sectors and Themes

The scope of the green economy is very broad. As sustainable development encompasses the whole global economy, it is necessary to divide the topic into manageable sub-themes. Inspired by the results of five mini workshops held in 2016 in Bolivia, Argentina, Mexico, Costa Rica and Colombia the (potential) role of innovations and quality infrastructure (QI) was studied in six important sectors of Latin America and the Caribbean economies, assessed as highly relevant by PTB's Green Economy Team [35], namely:

- Global value chains (GVCs) and sustainability standards
- Sustainable tourism
- Waste management, recycling and circular economy
- Smart cities
- Cleaner production (CP)
- Green building

The overall hypothesis is that standards help trigger and accelerate green innovations and the diffusion of green technologies through different impact chains, e.g. preparing or complementing smart regulations (compulsory standards) or fostering changes in consumer behaviour (voluntary standards). In all cases, standards must be accompanied by conformity assessment in order to be effective levers for change. The topic is of particular relevance in Latin America and the Caribbean region as pressure on national resources is high and will continue to grow. Examples of successful decoupling can provide important lessons for other countries.

35 There are other fields, where green innovations are highly relevant and Quality Infrastructure may play an important role, such as energy efficient household appliances. These thematic areas have been dealt with or will be dealt with in other PTB projects. For this reason, they are not analyzed in this paper.

The aim of this part of the study is to define entry points for quality infrastructure services to support the development of a green economy.

3.2. Global Value Chains (GVCs) and Sustainability Standards

The Global value chain (GVC) approach explains how the world economy is structured and continuously restructured (Gereffi, 2018, Gereffi et al., 2001, Pietrobelli and Rabellotti, 2011). Today, most goods are produced based on the division of labour among actors in different countries and regions. Standards and quality infrastructure are very important in GVCs as they ensure that value creation is not hampered by technical incompatibilities. Standards also help bridge geographical and cultural differences between producers and consumers, which is important for consumer health and safety. As the term GVCs is very broad, this chapter focuses on two of the key GVCs for Latin America and the Caribbean countries, namely a) bananas and b) the textile/garment value chain (TGVC).

3.2.1. Fresh Fruits (Bananas)

Fresh fruits, particularly bananas, are important cash crops in many Latin America and the Caribbean countries. Banana exports from Latin America and the Caribbean have grown 2.5-fold since 2001, reaching US-$ 6.4 billion in 2015.

In the transition towards a green economy, banana production entails a twofold challenge. On the one hand, it provides employment for many thousands of people, in regions with few alternative employment opportunities. Thus, banana production is an important source of

economic and social well-being. At the same time, it has severe negative externalities on the environment of the producing regions, and on the health of the people. Banana monocrops are especially vulnerable to the spread of plant diseases. Very high amounts of pesticides are applied, often by small airplanes, causing chemicals to drift to residential areas, soils and water bodies. Not only do these cause cancer and mutations in humans, but they are also devastating to the environment. Another serious problem is the large number of polyethylene bags used to cover the fruit, which are impregnated with pesticides. These bags contaminate natural environments and/or may poison cattle.

Green innovation and potential innovations

Several *incremental (green) innovations* have been introduced, using ICTs for less harmful pesticide application. Recycling of the bags used to protect growing fruit is important, but not yet widespread. A fundamental innovation would be to find an environmentally friendly replacement.

The transition to organic banana production is the most *radical end* of the innovation continuum. It requires new production processes, which mean a loss of economies of scale and products thus have to be marketed differently (marketing innovation). However, there are important co-benefits for the environment, such as preserving biodiversity and preventing pesticide contamination.

Several green side-innovations can also be found, for instance using banana peels to produce biological substitutes for plastic. These innovations mainly occur in consumer markets.

Main issues related to the banana value chain are:

- In recent years, infection with Sigatoka and Panama Disease has been extremely serious. This might induce producers to move to virgin territories. Clearing forests to establish new plantation areas should be avoided.

- Only two ISO standards apply explicitly to bananas and are not directly related to greening the GVC. There are other standards under ISO/TC 34/SC 3, several relevant for banana production. Standards relevant for green innovations are ISO 6561-2:2005 (determination of cadmium content), ISO 6633:1984 (lead) and ISO 6634:1982 (arsenic).

- There are two main groups of voluntary private standards related to sustainability: Fairtrade Labelling Organisation (FLO) and environmentally sustainable certifications.
  - The Fairtrade system seeks to improve the socio-economic conditions of workers. It also includes environmental minimum standards. A number of chemical substances are banned. So, Fairtrade certification can be seen as greening GVCs.
  - Fairtrade conformity assessment: FLO-CERT is the inspection and certification body for Fairtrade, independent of the standard-setting body. FLO-CERT inspects and certifies producer organizations in over 70 countries. To guarantee the credibility of the Fairtrade Mark, FLO-CERT operates an independent, transparent and consistent certification system according to ISO 17065, the international standard for certification bodies.

- Environmentally sustainable production: Since the early 1990s, a variety of voluntary standards and certification programs have become available to the banana industry, including organic agriculture, Rainforest Alliance, and ISO 14001.
  - Organic certified fresh bananas: Organic banana production uses organic fertilizers; weed control is manual and/or with machetes; pest problems are tackled using non-chemical methods.
  - The Rainforest Alliance certification promotes good farm management practices for natural resource conservation, improved workers' conditions and community relations, and environmental management. It is based on standards developed by the Sustainable Agriculture Network (SAN).

- ISO 14000 – Environmental management provides practical tools for companies and organizations to manage their environmental responsibilities. ISO 14001:2015 and its supporting standards such as ISO 14006:2011 focus on environmental systems to achieve this.

- Increasing private sector commitment: In recent decades, international banana corporations have been forced to improve their environmental and social performance. In 1991, Chiquita Brands International began its *Better Banana Project*. It now has an organic product line, as have industry giants Dole and Del Monte.

Certification, accreditation and the role of metrology

The banana industry is largely influenced by private and voluntary standards. *Conformity assessment* is done by control bodies (CB), sometimes linked to – but independent of – the standard setting bodies, such as FLO-CERT for the Fairtrade market. There are also independent CBs, accredited by the standard setting body (Rainforest Alliance). Organic certification is done by CBs accredited by the USDA or included in EU lists of CBs. Organic products sold in Latin America and the Caribbean need certification by a nationally accredited agency.

Metrology plays a limited role in the agricultural phase of banana production, except for determining the correct dose of agrochemicals. However, metrology does play a (potentially) very important role in monitoring the environment. After intensive use of pesticides over many years or decades precise measurement of chemical residues in soils and water bodies is important to protect the health of the local population and take adequate measures for transferring land to more sustainable banana production or food crops.

Metrology is highly relevant in banana ripening, usually done in the target countries. Here strict control of the main parameters (temperature and humidity) is required.

3.2.2. Mining Industry, Special Emphasis on Gold

Mining is an important economic activity in Latin America and the Caribbean. In 2013 the region accounted for 45 % of global copper production, 50 % of silver, 26 % of molybdenum, 21 % of zinc and 20 % of gold. In 2015 more than half the copper exported worldwide originated in Latin America and the Caribbean, particularly Chile. Gold exports have traditionally been concentrated in Peru, with Mexico gaining importance. In Chile, Peru and Ecuador, mining represents around 10 % of GDP. From 2002 to 2012, global gold prices increased by 500 %, and copper prices saw a strong upswing (commodity super-cycle). Recently, however, prices of most metals have fallen. [36]

When exploring its contribution to sustainable development and the (potential) contributions of quality infrastructure and innovations, it is necessary to distinguish between the formal mining industry and artisanal and small-scale mining (ASM). The world's largest mining companies, with activities in Latin America and the Caribbean include BHP Billiton (Australia-UK), Vale S.A. (Brazil) and Anglo American (UK and South Africa). There are no authoritative data on the number of ASM in Latin America and the Caribbean. Globally, there are estimated to be 15 million ASM in the gold extracting business alone and their mining methods differ depending on geology.

Despite these differences, there are common environmental and health-related challenges:

- Due to low conversion rates, vast amounts of raw materials need to be extracted and treated by physical and/or chemical methods.
- Preparation of an extraction site can lead to deforestation, land degradation through air, water and soil pollution, and also impacts local wildlife.
- Changes in water ecosystems: for the extraction processes, water has to be detoured and rerouted to the water bodies, sometimes contaminated with chemical residues.
- The use of potentially hazardous and contaminating chemicals, such as cyanide. Mercury as a processing substance, formerly very common, has largely been substituted in industrial mining, but is still common in ASM and illegal hard rock mining.
- The Minamata Convention on Mercury, a global agreement to reduce mercury pollution, recognizes the risks of using mercury in artisanal and small-scale gold mining.
- Some years ago, FLO introduced the *Fairtrade Standard for Gold and Precious Metals*, focused on good working conditions. In terms of environmental performance, the standard foresees continuous improvement and recognizes the difficulties in eliminating mercury and cyanide in mineral recovery. An Ecological Premium is offered on top of the Fairtrade Premium for ASM that only use non-toxic processes.

36 *http://www.mining.com/web/focus-latin-american-mining-industry* (Retrieved on 20/04/2020)

Green innovation and potential green innovations

- A Canadian mining industry publication lists 100 innovations in the sector, some of which may be loosely described as incremental green innovations (Minalliance 2012). Many of these innovations help improve the sustainability of the sector but are related to large-scale industrial operations. As big companies are closely monitored by international NGOs and media, the willingness to invest in greening the mining VC can be considered high.

- A series of potentially effective mercury and cyanide-free methods of extracting gold have been investigated, using physical concentration methods, magnets and/or safer chemicals, such as borax. However, these techniques have not yet reached most ASM, because mercury amalgamation is still more cost efficient and due to a lack of knowledge about the potential dangers of mercury. Developing non-toxic recovery methods and making them broadly accessible to ASM could be a very important green innovation in the gold GVC.

It can be assumed that most big players in Latin America and the Caribbean's mining business have their own and quality-assured testing and conformity assessment structures in place. However, there may still be entry points for developing quality infrastructure services. One example is effective systems for assuring the safety of production sites, e.g. to prevent accidents, such as the collapse of the Bento Rodrigues dam in Brazil in November 2015. This was one of the largest environmental disasters in Brazilian history. Remote sensing and other technologies might be useful tools for preventing similar events in the future.

As with the banana GVC, comprehensive environmental monitoring could be an important entry point. In ASM regions where mercury has been used for decades contamination of water bodies and soils is likely, but there are no authoritative data on the extent of the problem. Quality infrastructure institutions could offer services, e.g. to map mercury residues using high precision measurement methods. Partners could be environmental ministries or agencies in the relevant Latin America and the Caribbean countries. Also, FLO could be approached, as an international NGOs dedicated to improving the social and environmental performance of gold ASM producers. Environmental monitoring around industrial mining sites is also a relevant entry point. Water sources, soil and even air quality could be assessed periodically to ensure the health of the ecosystems and of the surrounding communities.

3.2.3. Textile – Garment Value Chain

Garment exports are important for Latin America and the Caribbean countries. After declining between 2005 and 2010 they later recovered. The textile-garment value chain (TGVC) has been under highly competitive pressure from Asian countries in recent decades. Most garment exports from Latin America and the Caribbean countries fall under the *maquiladora* model, where Latin America and the Caribbean companies receive semi-finished products (fabrics, accessories) from firms (mostly) in the USA. Here conformity assessment of the sustainability standards of inputs lies with the lead firms. However, a trend can be seen towards converting cut, make & trim companies into *full package suppliers*. This means that the contracted companies are also responsible for sourcing raw and intermediate products and must either be able to control the conformity assessment done in the source countries and/or rely on an own quality infrastructure to check delivered goods. Thus, demand for quality infrastructure services is growing in the TGVC.

Green innovations and potential innovations in the TGVC

Many actors are currently developing and applying green innovations in the TGVCs. One example is *Crailar Fibre*, a flax-based fibre, said to drastically limit the usage of water and chemicals in the VC; or *S.Cafe*, a fibre from Taiwan that uses recycled coffee grinds. Process innovations include efforts to develop more sustainable manufacturing methods to reduce energy and water consumption. A final group of innovations help companies throughout the VC to monitor their environmental performance, such as advanced Life Cycle Assessments (LCAs)[37] (see pilot interventions in chapter 4.3 Ecological footprints).

37 Life Cycle Assessment (LCA) is a tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle (cradle to grave). LCA provides an instrument for environmental decision support.

Main issues related to sustainability in the TGVC are:

- A sustainable textile and garment industry are crucial for socially inclusive industrialization: TGVC is an important source of formal employment in LAC, especially for unqualified female workers.
  - The textile industry is capital-intensive and uses many chemical inputs. As end products come into contact with consumers' bodies, controlling chemical residues is important for human health. Negative environmental externalities are also an issue; 17 % to 20 % of global industrial water pollution is from the textile industry.
  - The garment industry is labour intensive, and does not, per se, constitute a big environmental problem, as additional inputs are limited. Here the issue is labour conditions, and the social, not environmental, dimension of sustainability.
  - Textile related ISO standards focus on the chemical and physical characteristics of fabrics, process standards, and measuring e. g. chemical residues in the product. The garment related ISO standards (around 25) are fewer in number, more concerned with technical and product (not process) related issues, and not directly linked to the greening agenda.

Quality infrastructure can contribute in the following areas:

- The Best Available Technique Reference (BREF) were introduced in the EU in 1984 as the result of an exchange of information between various stakeholders. They relate to energy and water consumption, water discharge and the air and wastewater emissions of different metals and other substrates. The USA has similar regulations, such as the Clean Water Act (CWA). To be able to control these standards, a well-established conformity assessment infrastructure, including advanced metrology, is required.

- Another entry point might be to provide services for *full package suppliers*, as these companies have to be able to do own conformity assessment or assess the certifications done in source countries for fabrics based on traditional and innovative fibres.

- Monitoring the environment in TGVC producing regions, including indoor and outdoor air pollution and contamination of water bodies would also be an option, assisting companies and/or public authorities responsible for health and environment issues. Advanced metrology is important given the variety of chemical substances used.

3.3. Sustainable Tourism

Tourism is one of the world's largest industries. Latin America and the Caribbean countries receive around 8 % of all international travellers. The absolute number of arrivals has increased by around 63 % in the last 1½ decades. Income from international tourists has remained constant as a percentage of export earnings (slightly over 6 %). The main destinations in Latin America and the Caribbean are Brazil (2014: 6,430,000 arrivals) and the Dominican Republic (2014: 5,141,000 arrivals). Tourism is an important source of economic and social well-being, as it is labour intensive and there is often no direct competition among destinations to offer low-priced accommodation and services. However, it can also have negative impacts on the environment and the social fabric of communities, e. g. when hotels do not respect ecosystems or sexual exploitation of children is promoted. This led the UN-World Tourism Organization to coin the term *sustainable tourism*.

The main sustainability issues related to tourism are:

- Increasing diversity of tourism: Not only has tourism increased in the Latin America and the Caribbean region in, but it has also diversified. The discussion on *greening the tourism value chain* ranges from beach holidays in mass accommodations, e. g., in the Dominican Republic or Brazil, through diving and other sports in many Caribbean countries and outdoor adventure holidays to tourism related to cultural heritage, e. g. in Mexico or Peru and eco-tourism, e. g. in Costa Rica.

- Increasing demand for environmentally friendly tourism: More and more international travellers expect their tourism to be in harmony with nature or have limited ecological externalities. Surveys confirm an increasing consciousness regarding sustainability issues.

The broad-spectrum ranges from a vague desire for *sustainable vacations* to a clear commitment to eco-tourism or volunteer or service vacations, dubbed *voluntourism*.

- Sustainability standards along the tourism value chain: Tourism is a bundle of services. The VC goes from travel agents in the home countries, through providers of international travel, providers of accommodation, local travel companies, local food and event providers, local transport providers. The challenges for sustainability are very different as are the standards and related conformity assessment procedures. The criteria to define tourism as *sustainable* are diverse, depending on the type of tourism and how *sustainability* is defined. Most of the available standards do not require a technical conformity assessment in the strict sense.

- High number of standards and conformity assessment programs. In 2002, over 60 sustainable and ecotourism certification programs were identified. Some programs operate worldwide, some are regional, and most are national or local (CESD 2006: 17).

- The ISO/TC 228 (Tourism and related services) has published more than 30 standards, mainly related to quality of services (e.g. accommodation) and safety aspects, e.g. for diving. Some standards, however, contribute to the sustainability of tourism activities.

- In 1999 the World Tourism Organization, adopted the Global Code of Ethics for Tourism (GCET) to guide key-players in tourism development. More binding or at least more guiding standards are directly related to the various steps in the tourism value chain.
  - International travel: The International Air Transport Association (IATA) has introduced a carbon offset program. Travellers are invited to neutralize the GHG emissions of their journeys by giving money for carbon reduction projects.
  - An important initiative for travel agencies, local tour operators and providers of accommodations is Travelife, a *fair and affordable system which helps tour operators and travel agencies to manage and improve social and environmental impacts by complying with sustainability criteria.* [38]
  - There are many certification schemes for sustainable accommodation and their surroundings, some with a global scope. For instance, the *Blue Flag* program defines minimum criteria for environmental education, water quality at beaches and also for marina and other forms of sea-related tourism. In 2020, there are 95 beaches in the Brazil (13), Colombia (4) Dominican Republic (25), Mexico (53) certified for the *Blue Flag*. [39]

Entry points for quality infrastructure in greening the tourism value chain are:

- Given that a) a high and growing number of tourists are interested in sustainable travel and b) the number of certification schemes and labels is very high, the main challenge is to generate and maintain a high level of credibility for certificates. One option may be to promote the concept of *accredited certifiers*, following the ISO 17065 standard.

- A second option might be to work towards a meta-standard on sustainable tourism, which could certify that the standards and the related conformity assessment are in line with international good practices for sustainable development. Once established it could also foster continuous improvement in the sector's sustainability standards.

- At the national level, it may be possible to collaborate on initiatives to promote sustainability in gastronomic services, such as the *Plan Nacional de la Gastronomía Sostenible y Saludable* in Costa Rica. Regional and international organizations also promote sustainable consumption in the tourism sector, such as the *Colombian Programa Regional de Desarrollo Territorial Rural con Identidad Cultural* (DTRIC) [40]. Slow Food is a global organization, founded in 1989 to counteract the loss of local food cultures and traditions, the rise of fast life and combat dwindling interest in food, where it comes from and how our choices affect the world around us. Slow Food has today around 100 000 members in around 160 countries. [41]

38 *www.travelife.org* (Retrieved 07/04/2020)

39 *www.blueflag.global* (Retrieved 07/04/2020)

40 *http://www.diversidadbioculturalyterritorios.org* (Retrieved on 20/04/2020)

41 *www.slowfood.com* (Retrieved on 20/04/2020)

- A last option would be to link the issues mentioned under *green buildings* to the sustainable tourism topic, e.g. by promoting zero-energy accommodations for tourists.

3.4. Waste Management, Recycling and Circular Economy

Latin America and the Caribbean is one of the most urbanized regions in the world. With high population densities in cities and an emerging middle class, waste management is increasingly complicated. 8 of the world's 50 largest waste dumpsites are in Latin America (D-Waste 2014). In 2007, it was estimated that 369 000 tons of solid waste were produced per day in the urban areas of the region. Around 60 % of that waste ended up in inadequately controlled landfills (Hoornweg/Gianelli 2007).

At the end of 2008 the 32 states of Mexico were generating over 105 000 tons of solid waste daily: 53 % was organic waste, 28 % inorganic waste with commercial value (recyclable), and 19 % waste with no commercial value (Finpro 2010). The official recycling quota is low in most Latin America and the Caribbean countries. However, the case of Mexico suggests that there is a significant potential to approach a circular economy in most of the countries of the region. Also, processing organic waste, in the form of composting, can be a means of recycling and of improving impoverished soils.

It can be expected that in the future the goals of achieving a circular economy will be high on the international agenda, including in Latin America, given the climate change commitments of 2015.

The role of quality infrastructure in the area of waste management and recycling (WMR, including organic waste) is highly dependent on the types of waste treated and the final objective. While traditional and rural waste is often non-hazardous, an increasing amount of non-organic waste contaminates urban landscapes. Especially difficult is the treatment of medical and toxic waste. In 2014, e-waste in Latin America amounted to 3.9 million tons. The amounts are steeply increasing (UNU-IAS 2015).

Green innovations and potential innovations in waste management and a circular economy

Several fields in the *waste value chain* are implementing green innovations, such as sustainable production and consumption, end-of-use management and collection. Some of these innovations could be open to quality infrastructure services: Elimination of hazardous substances and a product design for repair, reuse, disassembly and recycling; waste segregation at source, etc. Other innovations are more social in nature, such as the transition to composting organic waste at home.

The main issues found in the waste management sector in Latin America and the Caribbean are:

- Differentiation between types of waste: Traditional and rural waste is often easy and non-hazardous to handle (e.g. food residues). When it comes to composting of organic waste for use as fertilizer for food production, the value chain has to be monitored to prevent toxic substances from contaminating food.
- Urban household waste is increasingly composed of materials with recycling potential and/or that pose a threat to health and the environment (e.g., batteries, e-waste).
- Urban mining: An increasingly important issue is the recycling of resources taken from urban buildings and infrastructure, when these have come to the end of their lifetime.
- Circular economy: The key concept of a circular economy requires that inputs into the production of consumer goods, but also to the building industry, have to be clearly identified and labelled in order to enable their re-introduction into production processes.
- Controlling waste handling: It is important to ensure high levels of recyclability.

Possible entry points for quality infrastructure bodies are:

- Establishing a materials' flow system within the extraction-production-usage-disposal/recycling system: It is important to monitor the amounts of raw materials that enter the production process, and how they are altered during use, how and in which quantities they enter the end-of-life stage, and thus, how they can be recycled. Changes in this flow over time require monitoring and open up entry points for quality infrastructure institutions. There are several ISO standards related to waste treatment (13.030), differentiated between a) waste in general, b) solid, c) liquid waste/sludge, d) special wastes (e. g., radioactive) waste and e) recycling of plastics (ISO 15270:2008), etc.

- Metrology, certification and accreditation of test labs are important for compost used as a fertilizer in food production to prevent contamination with toxic substances.

- Quality infrastructure plays an especially important role in monitoring air quality when solid waste is incinerated; in the case of landfills (the most common form of waste disposal in Latin America and the Caribbean) air and water quality must be precisely measured. Well-managed landfills also have potential to develop biogas projects. Here quality infrastructure can measure gas quality and monitor emissions.

- To achieve high levels of recycling *(circular economy)*, materials have to be precisely sorted. The major flows of material in the circular economy are steel, cement, plastics, paper and aluminium. Both household waste and urban mining are therefore important.

- The green economy project has worked in collaboration with the Sustainable Recycling Industries (SRI) program financed by the Swiss State Secretariat of Economic Affairs (SECO) and implemented by the Swiss Institute for Materials Science & Technology (Empa) and the World Resources Forum (WRF).[42] SRI recycling initiative supports national initiatives and implement pilot projects to improve the recycling of electronic devices and household equipment (e-waste). Currently, the program is implementing projects in Peru and Colombia (see e-waste pilot in chapter 4.2.2).

- In all the above cases, the conformity assessment bodies have to be accredited in order to make sure that their capabilities correspond to the complex tasks.

3.5. Smart Cities

The concept of *smart city* has been used since around the year 2000, although there is no clear definition. It mainly involves using ICTs to make city functions more efficiently and to improve services. Key aspects are smart governance, smart energy, smart building, smart mobility, smart infrastructure, smart technology, and smart healthcare and citizens.

In 2015, 79.9 % of the Latin American population lived in urban areas, compared with 56.6 % in East Asia Pacific, 37.7 % in Sub-Saharan Africa and 33.0 % in South Asia (World Development Indicators 2016). Around 70 % of GHG are now attributable to cities (EPA 2016). As city populations will increase, managing urban development is crucial for the transition towards a green economy. Smart and green cities rely on integrated and interconnected strategies and systems, such as energy, water, transportation, waste, and ICT, to ensure equal opportunities and protect the environment. A new set of ISO standards (ISO 37120: city indicators) outlines 14 categories of basic community needs to measure the performance of smart community infrastructures. ISO 37120:2014 is applicable to any city, municipality or local government irrespective of size and location. The indicators help cities assess where they stand and prioritize solutions. Standardized indicators mean that cities everywhere use the same measures, making it easier to collaborate and learn from one another.

42 *https://sustainable-recycling.org/* (Retrieved on 20/04/2020)

A 2016 UNCTAD study mentions eight Latin American cities, which employ the *Internet of Things* (IoT) to establish themselves as *smart cities*:

City	**Important IoT application**
Santiago	Automating pricing depending on traffic
Mexico DF	Smart and eco buildings
Bogota	Electrical and eco Subway
Buenos Aires	Public WiFi and public tech job programs
Rio de Janeiro	Weather, Crime, Traffic & Emergency Monitoring
Curitiba	Considered the *most ecological city*, i. e., through applying IoT in the urban transport sector
Medellin	Considered the most innovative city
Montevideo	Educational programs to create human capital

Source: UNCTAD 2016

The French National Standardization Institute (AFNOR) took the initiative of establishing ISO/TC 268: Sustainable development in communities. It develops a wide range of standards on sustainable development in communities, including on indicators for smart cities and for smart infrastructures. An important standard is ISO 37101 (Sustainable development of communities: Management systems – Requirements with guidance for resilience and smartness).

Sustainable development is clearly the overarching goal, while *smartness* is one of the means to achieve it. Smartness will help cities become more effective. This will only be possible by resorting to high technology that all cities may not be able to afford or maintain, which explains the reluctance of certain developing countries to go for smart city development.

Green innovations and potential green innovations

Smart city development is a concept in the making and will thus see a flow of innovations, some incremental, some more radical. One of the most radical is the huge amount of data gathered and shared in real time by different departments of city governments to overcome the dysfunctional separation between *administrative silos*. New forms of government-citizen interactions are created, e.g. for warning the people in the case of imminent flooding or air contamination or for reporting illegal dumping of waste. Sensors are a crucial element of smart city infrastructure, and their prices are declining, making smart applications increasingly affordable even for poorer cities.

Main issues and opportunities identified for achieving smart cities in Latin America and the Caribbean are:

- Cities are increasingly seen as the main entry point for making global development sustainable, due to their high levels of population, resource consumption and emissions.
- Issues of green and sustainable city development are increasingly high on the agenda of national and local policy makers, and of other stakeholders at the community level.
- In the future, we will see increasing efforts by local and regional policy makers to improve the environmental performance of city regions – and to demonstrate those efforts.
- IoT can also prepare cities to address, or even prevent, crises resulting from the convergence of climate change, urbanization and globalization.
- In recent decades, sensor prices have declined significantly, making this technical device increasingly affordable for cities in developing countries. This opens new entry points for innovations in smart cities, as these systems must be adjusted to the local conditions.

Possible entry points for quality infrastructure are:

- Measuring the environmental performance of cities: Firstly, quality of life in cities has to be continuously monitored and improved. This includes air contamination by nitric oxide from private transport as well as noise contamination, which is increasingly recognized as a source of discomfort. PTB could offer cities high-quality services to help them develop sensor networks adapted to their needs and conditions (*applied high-tech technologies*).
- There is also a trend to develop *sustainable cities* certifications based on local or international standards and indexes. There is potential for quality infrastructure to develop the corresponding conformity assessment for these standards and certifications.
- Innovative approaches to measuring the quality of urban spaces: At the same time, there are new approaches to measuring the quality of urban spaces, beyond easy-to-measure physical parameters (air, noise). For quality infrastructure to play a role, it has to demonstrate how data collection and more qualitative indicators can be brought together in a meaningful way.
- Calibration services: Sensor networks can provide city governments and civil society with huge amounts of data. Whether these are really helpful depends on the quality of the data and its conversion to information and knowledge. This requires the calibration of the sensors – a complex task in large urban areas – for different measurement purposes.
- Metrology research: Sensor-based environmental monitoring might require additional metrology research to find ways to accurately measure in real-time e. g., locally important pollutants in the air and water bodies.

3.6. Green Building

Buildings have significant impacts on the environment. During their construction, occupancy, renovation, repurposing, and demolition, they use energy, water, and raw materials, generate waste, and emit potentially harmful atmospheric emissions and sometimes effluents. The cement industry is one of the largest producers of carbon dioxide (CO_2). In 2002 it was estimated to generate up to 5 % of worldwide man-made emissions of the gas, of which 50 % was from chemical process and 40 % from burning fuel.[43] Every ton of Ordinary Portland Cement (OPC), the usual reference material for cement, produces a similar amount of CO_2.

In Latin America and the Caribbean, buildings consume 21 % of water, 42 % of electricity and produce 25 % of CO_2 emissions and 65 % of waste. Its 17 largest cities lose around 35 % of water to leakages; Rio de Janeiro, Brazil, has the highest rate at 58 % (ELLA n.y).

43 *https://www.wbcsd.org/Sector-Projects/Cement-Sustainability-Initiative* (Retrieved 07/04/2020)

This has led to the development of green building standards, certifications and rating systems aimed at mitigating the environmental impact of buildings.

Some densely populated cities emit less CO_2 per capita, such as Sao Paulo, Brazil, where emissions are half the national average. One core strategy to reduce CO_2 emissions is migration towards green buildings. By transitioning to such practices, Latin America and the Caribbean could reduce its energy consumption by 10 %. Unfortunately, developing countries face many obstacles, including upfront costs, lack of public policy to support it, lack of financing and access to information. Thus, green buildings still represent a niche market for expensive corporate offices or high-end residential buildings. However, significant opportunities to green the low-income housing sector are emerging in Latin America and the Caribbean.

Although national green building certification systems do exist in Latin America and the Caribbean, such as the Colombia Green Building Council and The Energy Efficiency Seal in Brazil, international certification systems are more widely used. Since most developing countries lack effective regulations to control resource use in buildings, these voluntary certification systems provide an important catalyst for the adoption of green buildings. The most successful international labelling initiative in Latin America and the Caribbean is the Leadership in Energy and Environmental Design (LEED) certification system, administered by the World Green Building Council (WGBC). This group of real estate professionals has grown quickly, with local councils in Mexico (2005), Brazil (2007), Argentina (2009), Colombia (2009) and Peru (2011). One main objective of Colombia's Green Building Council, for example, is to provide technical support to the government on pro-green building policies and incentives. Local councils also cooperate regionally via the WGBC American Network (ARN), dedicated to sharing valuable knowledge and experiences between network members. The top five countries for LEED certified (implemented) projects are Brazil (62), Mexico (29), Chile (13), Costa Rica (10) and Colombia (9).

The following are the categories of LEED certification, calculated on a 100-point assessment:

- Strategies for minimizing the impact on ecosystems and water resources;
- Water efficiency;
- Energy and atmosphere credits for energy efficiency;
- Materials and resources credits for sustainable materials and waste reduction;
- Indoor air quality, daylight and outdoor views.

Green innovations and potential green innovations for this sector are:

- A *cradle-to cradle* approach (McDonough and Braungart, 2002) to building construction: to ensure the main elements used can be re-cycled once the building has reached the end of its life.

- Greener materials for building: Product innovation, such as novel cement formulations, geopolymers, and novel concrete products are under development.

- Low carbon cement and wood products from sustainable forestry used for construction.

- Carbon-reducing cements, if developed for commercial-scale application, probably offer the safest, most economical and elegant carbon capture and storage (CCS) technology.

- Zero-energy buildings, in which the energy used is roughly equal to the amount of renewable energy created on site, or else by other renewable energy sources.

Challenges and opportunities for green innovation in this sector are:

- Higher upfront costs of green buildings thought to be generally 3–7 % higher than conventional buildings but may be up to 20 % higher in some cases.

- High impact of green buildings on climate change mitigation: It is estimated that every USD spent on energy efficiency equates to a 2.2-ton reduction in CO_2, whereas the same amount spent on renewable energy is only equivalent to a 0.4-ton reduction in CO_2.

- International cooperation and national funding are available for green buildings: Concern about climate change makes more funding available for green buildings, e.g. through the Clean Technology Fund (CTF). Another important tool to finance investments in green buildings in Latin America and the Caribbean is the International Finance Corporation (IFC). In collaboration with the World Green Building Council, the IFC also runs the international certification scheme *Excellence in Design for Greater Efficiencies* (EDGE). National funding programs should also be considered: In 2005, Brazil's National Agency of Electric Energy (ANEEL) assigned 50 % of its USD 876 million fund for energy efficiency projects to low-income housing.

- The use of internationally recognized green building standards simplifies the way green buildings are supported at local and national levels because they build on internationally acclaimed standards. If these standards are supported by a formal partnership of associations and organizations that represents the interests of the building industry, such as the case of the national Green Building Councils across Latin America, this may assist the expansion of the green building industry into other developing countries in the region.

- Multitude of ISO standards: More than 100 building standards have been developed by ISO technical committees ISO/TC 163, Thermal performance and energy use in the built environment, and ISO/TC 205, Building environment design.

- Reduced resource consumption: By transitioning to green buildings, the sector could reduce energy consumption by up to 50 %, water use by 40 % CO_2 emissions by 39 %, and solid waste by 70 %. (ELLA, n.y.: 4)[44]

Possible entry points for quality infrastructure are:

- Better standards for the cement industry: In general, the cement industry asks for support in developing new international standards for energy efficiency and CO_2 emissions, as well as developing or revising product standards and codes; for example, basing standards on performance rather than composition, and ensuring they are accepted by local authorities. This can be seen as a core responsibility of quality infrastructure agencies in the field of green buildings.

- Monitoring and improving the performance of green buildings: performance parameters should be strictly monitored to identify room for improvement, in lighting, heating, cooling, water usage and recycling, water quality etc. In the future the *Internet of Things* will provide important technical elements, such as sensors. These have to be calibrated in order to assure a well-functioning system.

- Cooperation with IFC and other international donors. IFC runs its own international certification scheme for buildings. They and other donors might be interested in having a partner competent in measuring efficiency standards and conformity assessment.

- Exploring the use of sustainable wood products in buildings. This is important to fixate carbon and improve the overall sustainability of buildings. Developing LCA methods for products and buildings themselves can also be a potential entry point.

44 Most of these optimistic assumptions about the cost-benefit ratios and effectiveness of green buildings are challenged by other authors on the topics

3.7. Cleaner Production

Cleaner production (CP) is defined as *the continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase overall efficiency and reduce risks to humans and the environment* (UN Environment). Product specific and management (ISO 14000) standards are implemented to ensure cleaner production. National Cleaner Production Centres (NCPC) have been established since 1995, mainly by UNIDO and UN Environment. This chapter will focus on CP and the relation to quality infrastructure in three important areas for Latin America and the Caribbean, tanning, mining and coffee.

3.7.1. Leather Tanning

The leather sector is of great importance for the economies of Latin America and the Caribbean countries, e.g. Argentina and Brazil. While in 2015, exports of hides, skins and leather accounted for nearly 15 % of the global exports, the figure was less than 1 % for leather goods. An effective quality infrastructure is crucial to the competitiveness and sustainable development of the Latin America and the Caribbean economies for two reasons:

- Export incomes and employment in Latin America and the Caribbean; in 2008, there were 90 000 formal and informal establishments in the leather and footwear sector, employing around 2.1 million people.

- Under inadequate management and control systems, tanning and dyeing processes pose a threat to health and the environment.

Tanning converts raw hides and skins into leather. The three main types are chrome, vegetable and aldehyde tanning, with chrome accounting for 80–90 % of total world production. Chromium occurs in two forms: the relatively stable and harmless *trivalent chromium (chromium III)* and the far more dangerous *Hexavalent chromium (chromium VI)*. Chromium interacts with fibres in the raw hide. Cadmium and lead-based pigments are used for dyeing to give leather a bright colour.

Hexavalent chromium, cadmium and lead may constitute health risks for customers when leather products contain residues above certain limits. Large and branded shoe manufacturers thus screen their suppliers' facilities. Examples are the Nike Chemistry Restricted Substance List (RSL) or the RSL established by IKEA. Most of the RSLs currently applied refer to the EU *Registration, Evaluation, Authorisation and Restriction of Chemicals* (REACH) regulation (2006). In the USA, the *Environmental Protection Agency* (EPA) and the *Consumer Product Safety Commission* (CPSC) control regulations and guidelines at the national level and regional authorities on state level.

Government regulation and conformity assessment by authorities in the target markets can also help to phase-out contaminating processes and induce innovation towards cleaner production. For instance, the EU has set the limit of 3 ppm as the generally accepted level for chromium VI in leather goods. For other heavy metals there are also strict limits, such as cadmium (60 ppm), mercury (60 ppm), and lead (90 ppm).

To demonstrate to buyers that leather goods pose no health risks to consumers, producing countries must have a reliable and accredited test infrastructure and laboratory system capable of detecting heavy metals/chemical residues. If not, producers have to rely on international conformity assessment providers or else they run the risk of product batches being refused.

While chemical residues in consumer goods can be phased out through pressure from lead firms in international value chains, voluntary standards and state regulation of the target market for exporters, there are also serious environmental health risks in the production countries, which are more difficult to overcome. The tanning process creates large amounts of wastewater. Due to the variety of chemicals used in the tanning process, this wastewater can have varying chemical characteristics. Some tanneries also produce large amounts of solid waste containing chromium. Chromium from leather tanning can make its way into air, soil, food, and water, and the most common forms of exposure are through inhalation of dust or fumes and contact with contaminated water. Workers in tanning facilities can inhale airborne chromium and can also be exposed by dermal contact from improper handling.

There are three possible ways to deal with these externalities:

- Regulations by the governments of producing countries;
- pressure by lead firms concerned about their image in international markets;
- voluntary standards, which motivate end consumers to choose products with higher than usual sustainability levels.

3.7.2. Green Innovations and Potential Green Innovations

To date there is no undisputedly clean leather production. Due to environmental concerns in large markets, the leather industry is under pressure to find effective alternative tanning materials.

Aldehyde tanning is often promoted as *chromium free* and, thus, environmentally sound. However, aldehydes often contain toxic formaldehyde. Formaldehyde-free aldehyde materials for tanning could be seen as a green innovation.

Some companies claim that their products are *organic* or *eco-leather*, based on **vegetable tanning**, for instance the fashion giant H&M. This suggests an awareness among consumers of the health and environmental risks of leather production. Vegetable tanning employs tannin, which occurs naturally in certain tree barks. There are some product-related disadvantages (reduced smoothness of the leather), and the environmental LCA shows no clear advantage of vegetable tanning. For instance, the time required for vegetable tanning is long (several weeks, compared to a few days with chromium). This leads to much higher energy demand and water consumption. Improved processes to overcome these disadvantages could also be seen as a green innovation.

Entry points for quality infrastructure services in the tanning industry are:

- The tanning process is potentially very dangerous for the workers, the communities, water bodies and soils. Chemical metrology is essential to prevent hazards to people and the environment. Physical metrology can help to improve the quality of the leather and the final products. Also, certification following OHSAS 18001 (Occupational Health and Safety Assessment Series) could be considered.
- In some countries, cooperation opportunities may be found in specialized institutes, like the Brazilian Institute of Technology in Leather, Footwear and Leather Goods or the CITECCAL in Peru (*http://www.citeccal.com.pe/*) to develop high precision measurement technologies and potentially, best practice laboratories. In other countries cooperation could be started by more generic institutes, such as INTI of Argentina.
- The analytical labs of tanneries or independent labs require calibration services and need to be properly accredited.

3.7.3. Coffee

Coffee production is of high importance for many Latin American and the Caribbean countries, due to the export income it generates. Dozens of millions of smallholder farmers and many hired workers earn their living in this sector. In Colombia, it employs an estimated 758 000 people (26 % of all agricultural employment) (Federación Nacional de Cafeteros de Colombia 2014, 5). Small scale farming is an important feature of coffee production; the British Fairtrade Foundation estimates that 25 million smallholders produce 70–80 % of the world's coffee.[45]

Coffee trees either grow with other plants that provide shade, which is beneficial for the trees and biodiversity, or, as in some Latin American and the Caribbean countries like Colombia, on densely planted mono-crop plots. For greening the coffee GVC maintaining or expanding mixed cultures can be seen as beneficial.

45 *http://www.fairtrade.org.uk/en/farmers-and-workers/coffee*

In terms of the green economy and green innovation, the first consideration must be the potential environmental externalities during the agricultural stage of the value chain. Harmful chemicals have been used to protect coffee plants and cherries from pests, fungi and insects. Many of these are banned in the EU and USA. Endosulfan has been phased out following the Stockholm Convention of 2001 and a worldwide ban is imminent. The remaining pesticides are still common.

Beyond the ban on Endosulfan there are no compulsory regulations related to coffee production; and even the ISO standards for coffee relate mainly to determining the proportion of insect-damaged beans, *acrylamide* content levels and moisture of the green and roasted beans. This has to do with the production stages following collection of ripe cherries:

- Cleaning: can be done by washing the cherries in tanks filled with flowing water.
- Pulping: is done by a machine which squeezes the cherries so that the skin and the pulp of the fruit are detached from the seed.
- Washing: because the pulping is done by mechanical means it normally leaves residual flesh and mucilage which has to be removed completely.
- Drying: to reduce the moisture of the washed coffee, it is dried either in the sun, in a mechanical dryer, or by a combination of the two methods;
- Roasting: in nearly all cases, coffee is roasted in the export target countries. Coffee roasting exposes the *green beans* imported from producing countries to temperatures of around 200 °C for around 12 to 15 minutes.

Even if coffee cherries have been exposed to potentially harmful chemicals, the final product (the seed) will usually not pose any health risk for consumers in the target countries. Drying at moderate and roasting at high temperatures usually eliminate any residues.

The main question related to greening of the coffee value chain is, thus, which environmental externalities have to be taken into account in the producer countries and how social standards can be assured along the value chain. Discussion about voluntary and private standards has therefore been high on the *coffee agenda* since the coffee crisis of 1999–2004.

Today, the coffee sector is replete with standards systems for sustainable production (e.g. Fairtrade Labelling Organisation (FLO), Organic (IFOAM), Rainforest Alliance, Utz Certified, Global coffee platform (formally Common Code for the Coffee Community (4C), the C.A.F.E. Practices from Starbucks', Nespresso's private AAA-label, etc.) each with its own label. Coffee sustainability standards combine environmental, economic and social goals with environmentally friendly production. Private and voluntary standards have been important for several decades. In 2009, 8 % of all green coffee exported had some form of certification of a credible claim of sustainability.

There are three main types of certification and labelling schemes:

- Organic coffee.
- Fairtrade coffee
- The Global Coffee Platform (formerly 4C).

Organic agriculture is a production method that uses both traditional and scientific knowledge to improve the health of the agro-ecosystem. Organic farms rely on locally available natural resources and the ecosystem management rather than external inputs such as mineral fertilizers and agrochemicals.

The *IFOAM* (Organics International) basic standards provide a framework for certification programs worldwide to develop their own national or regional standards. They also form the basis for the IFOAM accreditation program. Most certification programs used worldwide are accredited by IFOAM. For a product to be certified organic, all operators in the product chain – farmers, exporters, importers, processors, manufacturers, wholesalers and retailers – must be certified as acting in conformity with the regulations and standards of the certification program concerned. They must be certified by an *accredited* inspection body at least once per year.

There are several *fair-trade standards* developed by NGOs. The most widespread system is the *Fairtrade Labelling Organizations International* (FLO), an international NGO based in Germany. FLO defines fair-trade as a *trading partnership based on dialogue, transparency and respect* that aims for greater equity in international trade by offering better trading conditions to producers and securing their rights and improving trade rules and practices. For fair-trade conformity assessment, refer to 2.2 (banana GVC).

- The certification program of *Rainforest Alliance* (RA) focuses on the protection of the environment, forest conservation and sustainable management of natural resources. Certification is based on ten criteria, covering social and environmental sustainability. RA is a US-based NGO based with offices in Costa Rica and the Netherlands. It is the international secretariat for the Sustainable Agriculture Network (SAN), a network of conservation groups that uses the Rainforest Alliance Certified seal of approval.

- The *UTZ Certified Program* is based on a specific Code of Conduct: A set of social and environmental criteria for responsible coffee growing practices and efficient farm management. On its website, UTZ claims that in 2015, more than one million farm labourers and smallholders in 36 countries benefitted from the UTZ certification scheme. In the same year, the UTZ logo appeared on 13 500 products in 136 countries. The assessment of the compliance of products and processes with the UTZ codes of conduct is done by more than 50 certification bodies (CBs) around the world. A web-based Track and Trace system follows the UTZ certified coffee through the chain from grower to roaster, ensuring it is not mixed with non-certified coffee.

- Recently, organizations which have been certifying organic coffee for many years, such as IMO and Ecocert also have introduced their own fair-trade standards. The IMO Fair for Life standard combines social responsibility and fair-trade approach. The standard is applicable to a wider range of value chains than the FLO standard and gives more responsibility to the operators to define the fair-trade contract.

An increasingly widespread certification scheme is the *Coffee Community Network* (formerly Common Code for the Coffee Community, 4C). 4C is a verification system based on a code of conduct that every company/producer must implement. It starts with an internal monitoring process that 4C helps to set-up. Verification is then performed by independent third-party verifier companies approved by the Coffee Community Network. 4C was started in 2003 as a joint initiative of coffee producers, trade and industry, trade unions and NGOs to develop a global code of conduct aimed at achieving overall sustainability in the production, post-harvest processing and trading of mainstream green coffee. Through this verification system, it aims to exclude *Unacceptable Practices* (e.g. forced and child labour, prohibiting of trade union membership, having workers living below a decent standard of living, cutting protected forest, etc.) and support continuous improvement towards sustainable practices in the mainstream coffee sector.

Some private companies, such as *Starbucks* and *Nestle*, have developed and implemented their own verification system. Starbucks has developed Coffee and Farmer Equity (C.A.F.E.) Practices. These are buying guidelines that address their principles for ethical sourcing. Nestle's AAA Sustainable Quality Program draws on its relationships with its suppliers and partners to ensure coffee is produced to the highest quality standards. Furthermore, it also considers the social and economic value for farming communities, and environmental sustainability.

Green innovations and possible entry points for quality infrastructure

It is not easy to identify potentials for green innovation and a possible role for quality infrastructure in coffee production. Some of the past sustainability-related innovations in the area have been linked to marketing rather than technical innovations. One example is the (rather successful) effort to conserve shadow-growing of coffee (as opposed to mono-crop plantations) by selling coffee as *bird-friendly* and achieving better prices along the value chain. Most of the comprehensive and label-oriented standard organizations have their own conformity assessment schemes in place.

Two technical innovations have long been tested, but have not yet achieved a breakthrough: 1) developing alternatives to firewood heating of coffee-drying equipment in countries such as Costa Rica, where large-scale processing is common; 2) converting residues (coffee pulp, mucilage) into an effective fertilizer; this also applies to large-scale processing plants in some Latin America and the Caribbean countries.

Metrology: Measurement of technical parameters in coffee production involves determining the moisture of coffee beans and acrylamide content, the latter mainly relevant for roasted coffee. Costa Rica is implementing a *National Appropriate Mitigation Action* (NAMA) Program in its coffee sector. This requires an effective Measurement, Reporting and Verification system.

The green economy Project supported this life cycle analysis for coffee in Costa Rica and Colombia (see chapter 4.3.1).

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4. Pilot Cases

4.1. Overview

The pilot interventions were the central instrument of the Regional Project to explore possible contributions of quality infrastructure for innovation in the green economy. In the first project phase, national quality infrastructure institutions from 24 countries submitted 36 proposals for interventions in the priority themes identified in the baseline study. The Advisory Committee approved the following six pilot interventions, which we present in pairs under three headings:

- Waste management
  - Management of hazardous waste in laboratories and
  - Quality in the value chain for e-waste
- Ecological footprint
  - Product category rules and
  - Water footprint
- Environmental monitoring
  - Cost-effective air quality measuring instruments and
  - Proficiency test on air quality

In each pilot, quality infrastructure and the green economy representatives from different countries worked together. Experts brought additional knowledge to the cooperation context. Each pilot aimed to identify the specific needs of the green economy for quality infrastructure services and to make them available in a manageable format.

4.2. Waste Management

4.2.1. Management of Hazardous Waste in Laboratories [46]

Testimonial

"This pilot project was important as most of the participating laboratories shared the same experiences: having little to no hazardous waste legislation, no waste disposable industries available and finally the laboratories had no sustainable plan to dispose of its hazardous waste (...). The pilot project assured a holistic sustainable way to managing hazardous waste both, inside and outside the laboratory. It is amazing that this quality approach not only offered a solution to protect the environment, but could drastically improve safety for workers in the laboratory, too... I liked the methodology as a step by step approach, and in a relatively easy way this process could be integrated into our working procedures..."

Saira Knox, Trinidad and Tobago Bureau of Standards

Context

Hazardous waste refers to a type of waste with properties that make it dangerous or capable of having a harmful impact on human health or the environment. Due to the perils resulting from hazardous waste, its management is heavily regulated on both national and international level. At international level, the Basel Convention (1992) is the most relevant. By this convention, ratifying countries commit to minimize the generation of hazardous waste, to ensure that adequate disposal facilities are available, to control and reduce international movements of hazardous waste, to ensure environmentally sound management of waste, and to prevent and punish illegal trafficking.

Adequate management of hazardous waste is challenging due to special measures needed to be taken during different stages of its lifecycle including generation, transportation, storage, recycling, treatment and disposal.

Hazardous waste is generated from many sources whereas one of the sources is the laboratories. This pilot is following the principle to bring first the house of quality infrastructure (QI) in order, before approaching and encouraging others to follow.

Management of Hazardous Waste in Laboratories

Objectives	■ Participating partners identify the most practical and application-oriented solutions for the management and disposal of hazardous waste in developing countries ■ To systematize the experiences and identify possibilities of scaling-up
Duration	From June 2017 to July 2019
Participants	Institutions of the quality infrastructure (QI) from Barbados, Ecuador, Grenada, Guyana, Honduras, Jamaica, Peru, Suriname and Trinidad and Tobago as well as the CARICOM Regional Organization for Standards and Quality CROSQ
Main activities	1. First Training Workshop on Hazardous Waste Management in Laboratories. August 14–17, 2017, Kingston, Jamaica 2. Implementation of Action Plans to put into action HWM in a pilot laboratory in each country, supported by thematic virtual meetings and online consultancy. August 2017 to May 2018, online 3. Second Training Workshop on Hazardous Waste Management in Laboratories, Train the Trainers Workshop & National Workshop for stakeholders of Trinidad and Tobago, May 7–15, 2018, in Port of Spain, Trinidad and Tobago 4. Systematization of experiences. June 2018 to July 2019, online

Factsheet 1: Management of Hazardous Waste in Laboratories

46 Dr. Alexis Valqui assisted the pilot on hazardous waste management in laboratories and wrote the corresponding case study

QI Impact Chain for Hazardous Waste in Laboratories

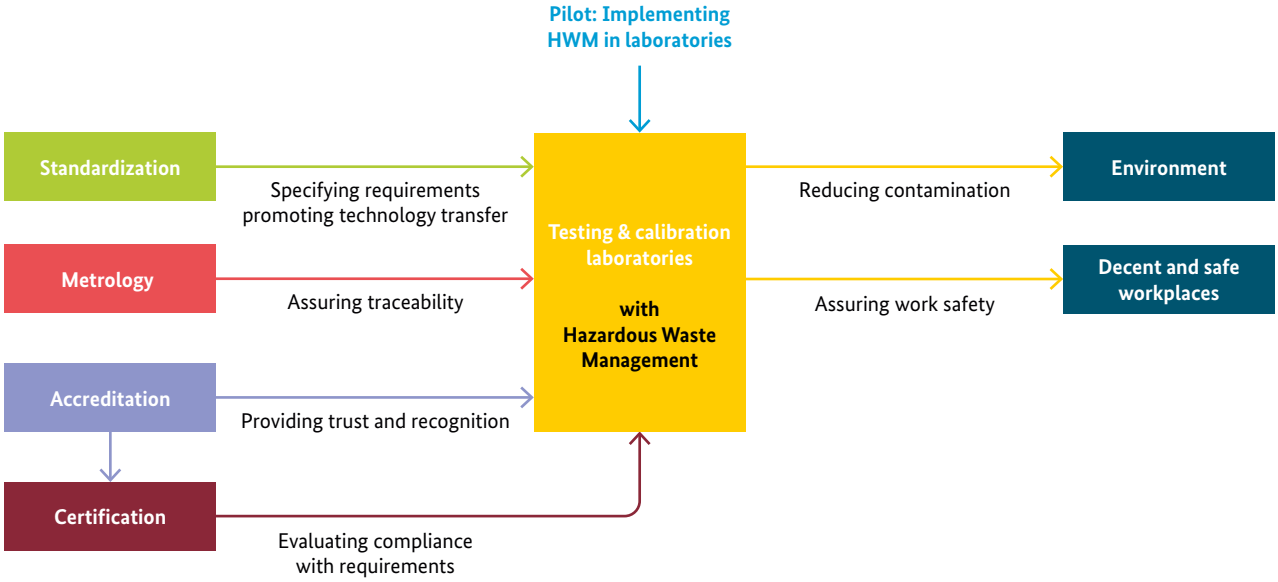

Figure 7: QI Impact Chain for Hazardous Waste in Laboratories. Source: Own elaboration.

Main results

"Expanding the chemical waste management system to a 10-step implementation approach was the highlight of the pilot. This is where "rubber hits the road" and the achievement was a practical approach for laboratories to address the management of waste at each waste lifecycle stage, namely waste; generation, transportation, storage, recycling, treatment, and disposal... Changes at TTBS include creating a quality group to address HWM concerns inside and outside the lab. This group is now empowered to continuously look at maintaining and improving the entire chemical/waste management life cycle at TTBS. There is also a work procedure for the group within the quality management system to ensure that the recommendations and concerns of the HWM group reaches top management...

Using risk and project management processes allowed the laboratories to do its part towards a circular economy".

Saira Knox, Trinidad and Tobago Bureau of Standards

Through this pilot, hazardous waste Management (HWM) in laboratories has been introduced in at least one pilot laboratory in six Caribbean and three Latin-American countries.

As part of the experience, useful formats and the following 10-step approach has been developed (the sequence can be used flexibly):

1. Form a Planning Committee
2. Analyse the current HWM situation
3. Identify a suitable pilot lab in your institution
4. Identify and communicate HW findings to staff and decision makers of your institution
5. Create a chemical inventory for the pilot lab
6. Label the vessels used in the pilot lab based on the global harmonized system
7. Implement safety measures in the pilot lab
8. Perform the chemical analysis: substitute, reduce, re-use, recycle, dispose
9. Integrate HWM in the quality management system or create standard operating procedures
10. Formalize the HWM committee and scale up HWM to cover all laboratories of your institution

As part of the process, a manual has been revised and finally published: Meyer (2018): *Hazardous Waste Management for Laboratories*. PTB, Braunschweig.

Lessons learnt

- Hazardous Waste is a real problem for laboratories in the region; and not everybody is aware of that.
- Besides the regulation, there are no market incentives that motivate laboratory staff and owners to implement HWM in their laboratories. Nevertheless, participants were sufficiently motivated based on their responsibility. Additional motivation was generated through the realization that HW is a direct health threat for laboratory staff.
- Standardized procedures, manuals and guides exist and are helpful for implementing HWM in laboratories, but in-depth chemical knowledge in the laboratories is a prerequisite for the implementation of a sound and sustainable HWM system.

Outlook

- The recognition of laboratories that implement HWM must be promoted. One option is the development of a specialized certification scheme, another option is that in future the accreditation process covers the implementation of HWM, too. Furthermore, it has to be evaluated, if the development of standards could support the HWM implementation.
- The HWM in Laboratories with a focus on national HWM in laboratories dissemination strategies should be strengthened. The national metrology institutes, with their chemical expertise are ideal actors to promote a national HWM implementation strategy as part of a national green economy policy.

4.2.2. Quality in the Value Chain for E-Waste [47]

Testimonial

"It is of utmost importance for current and future generations to develop deep commitment actions related to environmental care. (...)

[The] project was planned and successfully developed, and allowed to expand the knowledge on the management of this dangerous waste, and to reveal the social problems that most Latin American countries experience in the environmental field..."

Diego Trávez, Ecuadorian Standardization Institut (INEN)

Context

E-waste generation is on the rise and resulted in 50 million metric tons in 2018 worldwide. Approximately one quarter of this giant amount is made up of personal digital devices, like smartphones and laptops. These electronic goods contain hundreds of different materials, such as the toxic substances lead, mercury, cadmium, and arsenic but also valuable elements like gold, silver and copper. Correspondingly, e-waste is both a potential economic resource as well as a hazardous waste, posing a threat for environment and human health.

Although the parties of the Basel Convention (adopted in 1992) recognized that hazardous waste must be managed safely, disposing and recycling e-wastes is still challenging due to the number of different materials. Thus, the growing amount of waste electrical and electronic equipment (WEEE) requires the implementation of innovative management approaches to classify and to sort the minerals for reuse and to manage toxic components safely.

By supporting the quality infrastructure (QI) to develop services for the value chain of e-waste, this pilot sought to provide examples on how to improve the management of e-wastes. The development of standards and enhancing conformity assessment ensures that e-wastes can be managed properly, promotes the role of recycle companies, decreases health threats and strengthens e-waste as an economic resource.

Main results

"... it was enriching to work and share a dialogue table with representatives of public institutions, private companies and civil society, who according to their field of competence contributed in an important way with their knowledge, to improve in our country the management of WEEE. I thank the German Metrology Institute – PTB and INEN as promoters, and the different institutions that were present, to carry out this project that is very important for our country and the environmental protection.

E-Waste Value Chain

Objectives	■ Participants identify the most practical and application-oriented solutions for the management and disposal of hazardous electrical and electronic waste in developing countries ■ Systematization of experiences and identify possibilities of scaling-up
Duration	From July 2017 to July 2019
Participants	Quality infrastructure (QI) institutions from Honduras (OHA), Ecuador (INEN), Argentina (INTI), Brazil (INMETRO) and Mexico (ema)
Main activities	1. Training Workshop on Circular Economy, Requirements of the ISO IWA 19:2017 – Guide for the Sustainable Management of Secondary Metals and Internal Auditors 2. Audits to evaluate compliance level with requirements of ISO IWA 19:2017 in two waste electrical and electronic equipment (WEEE) recycle companies 3. Workshop for Analysis of the WEEE management value chain for cell phones and televisions, with value chain-based methodology. Implementation of the action plan defined.

Factsheet 2: E-Waste Value Chain

47 Dr. Alexis Valqui and Mauro Rivadeneira assisted the pilot to the e-waste. Mauro Rivadeneira wrote the corresponding case study.

QI Impact Chain for E-Waste

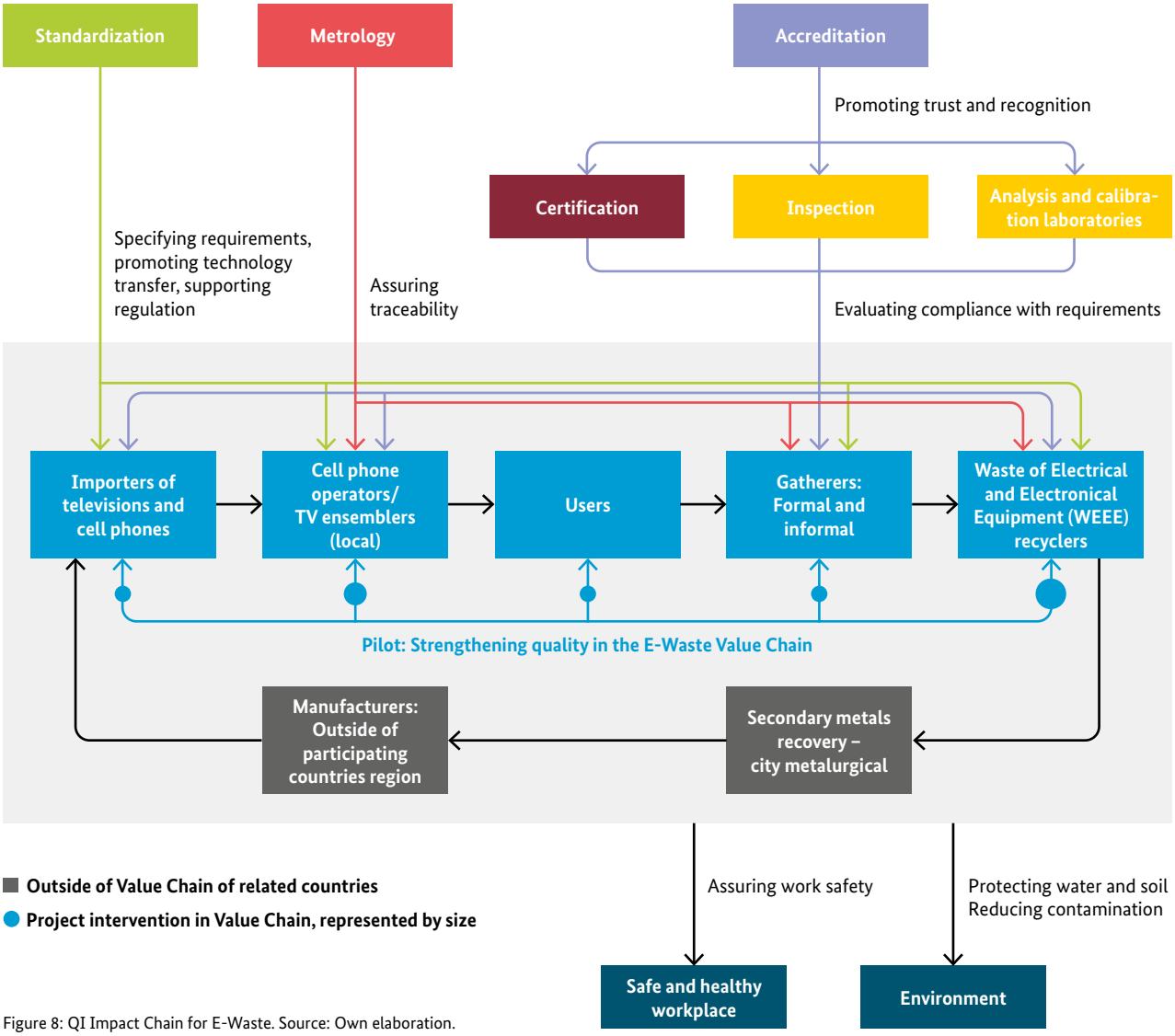

Figure 8: QI Impact Chain for E-Waste. Source: Own elaboration.

We are confident that this project will be very useful for our authorities who develop public policies in order to act aligned with international practices, mitigating the environmental impact we cause as humanity, with the development of daily activities, raising awareness and taking care of our planet from any place and scope we develop in our activities".

Diego Trávez, Ecuadorian Standardization Institut (INEN)

1. Analysis of the status quo of international standardization and regulation on Waste Electrical and Electronic Equipment.
2. Audits to recycling companies in San Pedro Sula provided information regarding the status quo of the application of international practices in the country.
3. Adoption of the ISO IWA 19:2017 Guide in Ecuador.
4. Analysing the value chain of e-waste and the existing gaps of services of the QI in Ecuador with participation of the representatives of the WEEE Recycle value chain, QI and regulatory bodies, resulting in an action plan.
5. Increased capacities to implement and evaluate the compliance with the requirements of the ISO IWA 19:2017 Guide.

Lessons learnt

- Waste electrical and electronic equipment is an important kind of hazardous waste and its proper management is a mayor challenge in the region.
- The recycling rate for WEEE is still small, compared to the amount of equipment that go into the market.
- Despite of regulatory approaches there are hardly market incentives for WEEE recyclers to implement certifiable systems.
- In addition to the ISO IWA 19:2017, there are certifiable standards for recycling such as Responsible Recycling (R2) and ISO management systems, as well as regulations. Furthermore, in the region exist internationally recognized accreditation schemes, which could be applied with the corresponding political support.

Outlook

- The constant increase in the volume of WEEE generated by the technological progress, as well as the growing shortage of secondary metals in primary mines, makes recycling increasingly profitable and necessary, which is why it should be considered as a component of a national green economy policy.
- In the regulatory sector, it is important to define technically the monitoring schemes to be used, considering internationally recognized practices for standardization and conformity assessment.
- The recognition of WEEE recyclers that implement certifiable management systems should be promoted. There are many certification schemes available and the recycle companies should have an incentive to choose them to demonstrate compliance.

4.3. Ecological Footprints [48]

4.3.1. Product Category Rules

Testimonial

"One of the greatest challenges that our countries have in environmental matters is to ensure that all goods and services that are developed or acquired have the least environmental impact. This can only be possible with tools such as the Life Cycle Assessment and the use of Product Category Rules, that allow us to know objectively the real impact of products and services (from cradle to grave) and help us make decisions consistent with our environmental, social, economic and developmental policies. These first experiences through the PCRs pilot have been very useful for the design and validation of our national program."

Luis Rodríguez, Costa Rica´s Environmental Quality Department of the Ministry of Environment and Energy

Context

The consumption patterns we are surrounded by every day have a big impact on the environment. Each product or service requires resources during different stages of its lifecycle and is freighted with environmental consequences. Considering the limited capacity of the planet to regenerate resources and the increasing use of resources, the need to assess and reduce environmental impact of products and services is important. Life cycle assessment (LCA) is an accounting tool that enables to quantify this environmental impact throughout all stages of a product's or service's life cycle.

LCA allows for a comparison between the environmental performance of products that are assessed in the same standardized way. LCA data is used as basis for eco-labelling, also known as environmental product declarations (EPDs). One important step to set up EPDs is the development of Product Category Rules (PCRs). These PCRs describe the requirements, guidelines and rules that a product must comply with to be able to receive a specific EPD.

48 Andrea San Gil and Laura Mora assisted the pilots on the ecological footprint. Laura Mora wrote the two case studies.

However, LCA and PCRs are relatively new in Latin America and the Caribbean (LAC). Due to this, the institutions of the quality infrastructure (QI) are just starting to build up the high levels of technical competence, resources and technology and software needed to develop an environmental assessment for a product. The Physikalisch-Technische Bundesanstalt, on behalf of the German Cooperation, launched in cooperation with the regional QI organizations of LAC (COPANT, IAAC and SIM) this pilot project to enhance the QI services to develop and implement PCRs.

Pilot in Product Category Rules

Objective	To develop the capability of quality infrastructure (QI) organizations to offer QI services related to PCRs development according to ISO/TS 14027:2017 in selected LAC countries
Duration	From July 2017 to July 2019
Participants	QI institutions from Argentina (INTI), Brazil (INMETRO), Colombia (ICONTEC), Costa Rica (ECA and INTECO) and Trinidad and Tobago (TTBS)
Main activities	1. Preparation of Pilot Project including identification, selection and assessment of participating countries 2. Training activities on PCR development 3. General follow-up with the partners on the implementation of accreditation/metrology services 4. Individual follow-up for implementation of national activities (with each participant country) 5. Closing Dialogue: Applications of PCR development for Latin America

Factsheet 3: Pilot in Product Category Rules

QI Impact Chain for Product Category Rules

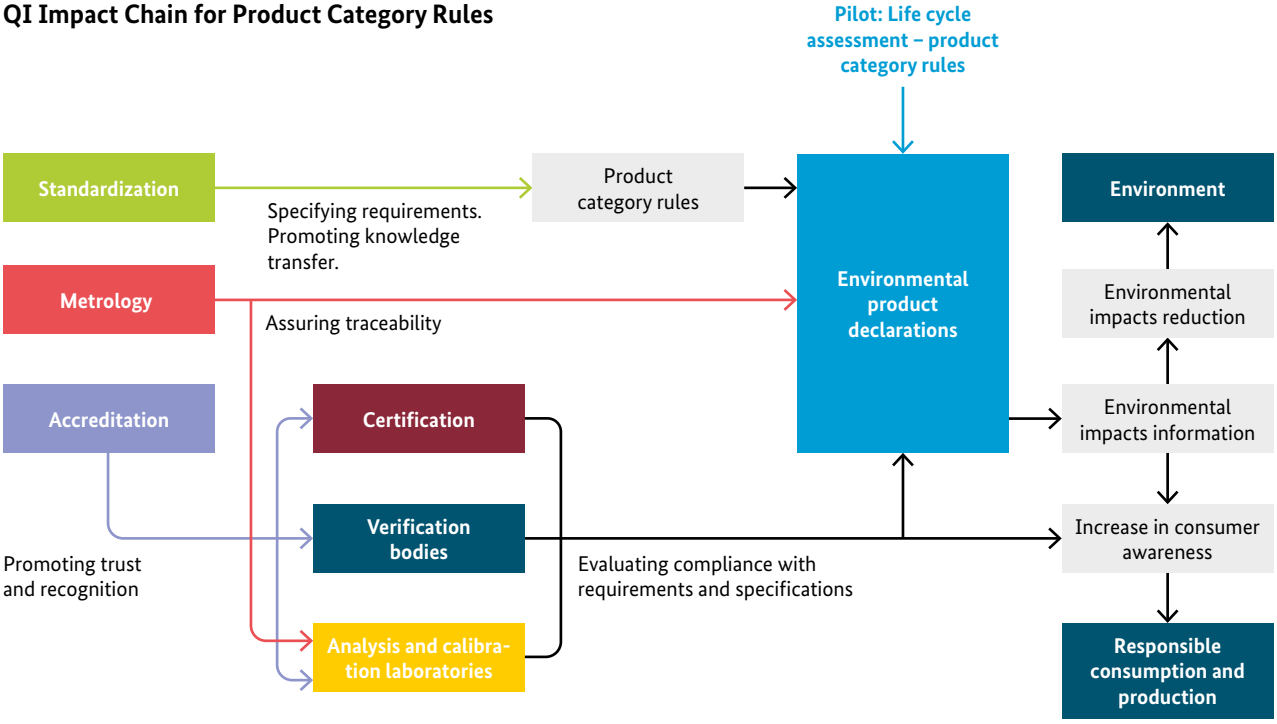

Figure 9: QI Impact Chain for Product Category Rules. Source: Own elaboration.

Main results

"In a country where the coffee exports represent 8.19% of the GDP associated with agriculture, with an organized sector and an increasingly demanding market, we have the most appropriate context to be pioneers in the implementation of these schemes, to demonstrate its technical feasibility and its applicability.

It is well known that Europe is preparing to request environmental product declarations in the coming years and Costa Rica as a supplier cannot be left behind. The support received by PTB's green economy project has allowed us to successfully conclude this first step towards the differentiation of our products due to the good environmental practices we develop."

Victor Vargas, Costa Rican Coffee Institute (ICAFE)

1. Enhanced capacities of the countries' QI due to online coaching and specific workshops and trainings

2. Collaboration between representatives of different countries to align criteria and support the development of PCRs.

3. Colombia has developed a procedure for the preparation of PCRs

4. Technical inputs and technical review for the development of the first PCR at Mesoamerican level to *Prepare Life Cycle Analysis of Costa Rica Green Coffee for Export*

Lessons learnt

- LCA and specifically the development and use of PCRs require a level of competence and ample technical training, which can take a long time to be achieved in certain countries and it depends of the development level and the necessities of each country has.

- The awareness and knowledge about the potential as well as the support to develop the tool by decision makers at the national, institutional, sectorial and business levels is a critical factor for the success of the development of this type of scheme.

- It is necessary to build a capacity development structure that ensures that knowledge is acquired and managed over time, and each institution must achieve a level of leadership that allows it to ensure the growth of its schemes and not depend on external support for its continuity.

Outlook

- It is necessary to define communication strategies with the aim to raise awareness and the understanding of particularly decision makers and consumers about eco-labelling's relevance and the involved processes.

- Most of the participating countries have little development in LCA and PCRs and therefore they do not use them for decision-making. So, there is much potential, but the necessity of each country should be considered to define specific work plans.

4.3.2. Water Footprint

Testimonial

"It is necessary to start measuring the impacts of the goods and services that we produce and the impact on water is fundamental. However, to achieve this we require the commitment of the government and most importantly, the private sector.

For this to occur we need to give promotion to the tools of LCA and water footprint to build awareness in consumers and companies. It has been very important for our institution to receive support from projects to achieve this goal."

Diana Fandiño, ICONTEC Colombia

Context

Fresh water is vital to life. With the growth of world's population and a change towards more resource-intensive consumption patterns in some parts of the world, the demand for direct and indirect fresh water has drastically increased globally, resulting in water stress in many regions.

To determine how big are water use related effects from consuming some particular goods and services, the water footprint (WF) has been developed.

The water footprint forms part of the family of footprint indicators. Meanwhile Life Cycle Assessment (LCA) has been developed as an accounting tool to quantify a product's or service's environmental impact ("environmental footprint") during its entire life cycle, the water footprint is focused on quantifying and monitoring direct and indirect impacts from water use for products and services. The water footprint allows to prioritize investments and consumption choices regarding water related impacts and can contribute to an informed water management.

However, both the methodology of Life Cycle Assessment and water footprint are new approaches in Latin America and the Caribbean. Correspondingly, the institutions of the quality infrastructure (QI) in the region are just starting to build up their levels of technical competence, resources and technology needed to develop this type of assessment for a product. The Physikalisch-Technische Bundesanstalt, on behalf of the German Cooperation, launched in cooperation with the regional QI organizations of LAC (COPANT, IAAC and SIM) this pilot project to enhance the QI services for the assessment of Water Footprints.

Water Footprint Pilot

Objective	Develop technical capacity, new and strengthened QI services and schemes in accreditation bodies, certification/verification bodies and metrology institutes in water footprint assessment in selected Latin American countries.
Duration	From July 2017 to July 2019
Participants	QI institutions from Colombia (ICONTEC), Brazil (INMETRO), Mexico (EMA), Argentina (INTI), Costa Rica (ECA and INTECO)
Main activities	1. Preparation of the pilot project including identification, selection, and assessment of participating countries 2. Training activities about Water Footprints and quality infrastructure (QI) 3. General follow-up for implementation of accreditation/metrology services 4. Follow-up for implementation of national activities 5. Activities according to national action plans 6. Closure Dialogue event: sharing of conclusions and experiences

Factsheet 4: Water Footprint Pilot

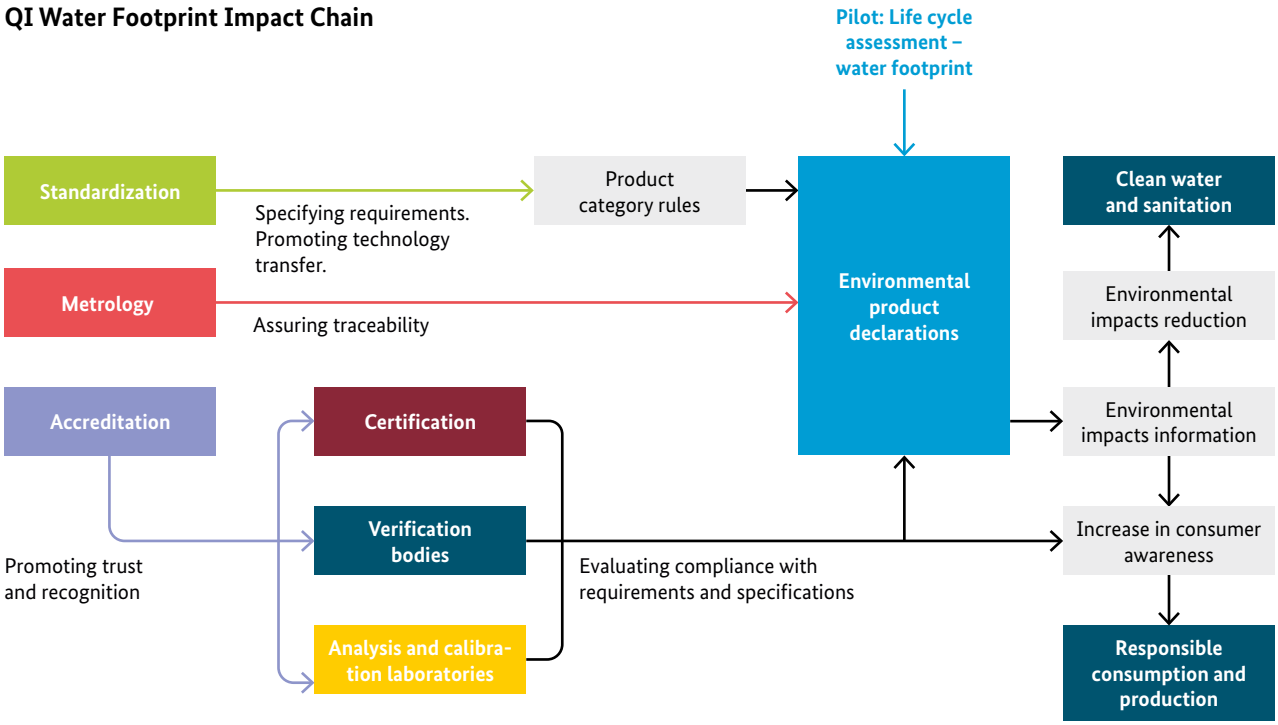

Figure 10: QI Water Footprint Impact Chain. Source: Own elaboration.

Main results

"ECA constantly seeks to be at the forefront of accreditation issues, we look for the opening of schemes that generate an important environmental and social impact, while we seek the right allies to do so, such as PTB.

The Water Footprint scheme has not been the exception and the accredited third-party organizations that verify the Water Footprint of products, services or organizations must ensure that the information is accurate, coherent and transparent.

For ECA, being able to provide a new accreditation scheme like this facilitates stakeholders, such as MINAE, ICAFE, confidence in the processes and information provided for future decision making."

Mariluz Quirós, Ente Costarricense de Acreditación

1. Carried out a training on Water Footprint and quality infrastructure in November 2017 in Colombia.

2. Enhanced capacities of the countries' QI due online coaching and specific workshops and trainings, e. g.
   a) Training about Life-cycle assessment for Colombia in June 2018
   b) Workshop on water management and industrial sustainability for Brazil, September 2018.
   c) Workshop on Water Footprint and quality infrastructure for Argentina, August 2018

3. Elaborated accreditation scheme for environmental footprints (including water footprint) by ECA (Costa Rica) as well as verification process developed by ICONTEC (Colombia).

Lessons learnt

- The criteria for the operation of this type of schemes in the QI are still not completely clear, which makes it difficult for countries to make decisions and develop them.

- Some of the QI institutions have the capacity and competence to develop these schemes, but the current demand for these types of services is still minor. This reflects both the need to strengthen QI in this area and in parallel to raise awareness of the private sector, government and consumers for water use related effects of offered products and services.

Outlook

- To ensure a better understanding of the scope, reach and potential for efficiency and sustainability of these tools, it is necessary to raise awareness and transmit knowledge (about LCA and Water Footprints) with communication strategies and awareness-building activities directed to all stakeholders, mainly to decision-makers in the private sector and the final consumers whose purchasing decisions ultimately influence public and private sector policies.

- Most participating countries had little experience with LCA and Water Footprint and supporting policy decision making. So, there is plenty of potential in supporting these countries' sustainable growth through technical training and specialist consultations. Evaluating the specific needs of each country separately is of utmost importance to identify their progress and to define specific action plans for each country.

4.4. Air Monitoring[49]

4.4.1. Proficiency Test for Air Monitoring Networks on Carbon Monoxide

Testimonial

"The project was extremely important to generate links between the metrological institutes and the organizations that carry out air quality measurements, and the possibility of sharing experiences and knowledge between the different organizations and networks that participate in the intercomparison."

María Inés de Casas, Deputy Operational Manager
of the Automatic Atmospheric Monitoring Network in the
Government of the City of Buenos Aires/ Argentina

Proficiency Test for Air Monitoring Networks on CO

Objective	Improve the measurement capabilities of air monitoring systems in Latin American and Caribbean Cities
Duration	From August 2017 to July 2019
Participants	Argentina (INTI, APrA Buenos Aires, Nacional Air Monitoring Network), Brazil (INEA Rio de Janeiro and INMETRO), Costa Rica (Univ. Nacional, USAC and LACOMET), Guatemala (SNC and INSIVUMEH), Mexico (Univ. Querétaro y CENAM), Trinidad and Tobago (EMA and TTBS), and as an observer: Paraguay (NMI)
Main activities	1. Preparatory workshop in Buenos Aires in May 2018 2. Proficiency test on carbon monoxide (CO) in six participating countries 3. Sharing of the test results and recommendations for improvement of measurements 4. Systematization of experiences

Factsheet 5: Proficiency Test for Air Monitoring Networks on CO

49 Dr. Ulrich Harmes-Liedtke assisted the pilots on air monitoring and wrote the corresponding case studies

Context

The quality of air is a major concern due to its impacts on health of citizens. In many regions of Latin America and the Caribbean air pollution is severe due to waste incineration, wildfires as well as vehicles. So far, the monitoring of air quality in the region is still at the beginning. This is also the case for cities with a high population density and high vehicle emissions.

Currently, the operators of many local measurement stations are not sure about their measurements' performance as no proficiency tests had run so far to verify their results. Furthermore, the employed instruments of the operators are hardly calibrated, and the staff does not have the capacities to calculate the measurement uncertainties well. As a result, the validity and integrity of air quality data is not ensured. However, a quality assured air quality monitoring system of selected parameters provides the prerequisite scientific basis for developing regulations, setting objectives and planning measurements and is therefore key to ensure citizens' health.

The pilot project seeks a closer cooperation between the national metrology institutes and the outdoor air monitoring networks to significantly improve data quality by running a proficiency test for the parameter of carbon monoxide. This enables the monitoring networks to determine their performance for this parameter and to discuss quality assurance measurements. By enhancing the traceability and the comparability of air-quality measurements, this cooperation can contribute to a reliable data base and correspondingly back air quality policies in the region.

QI Impact Chain for Air Monitoring Proficiency Test

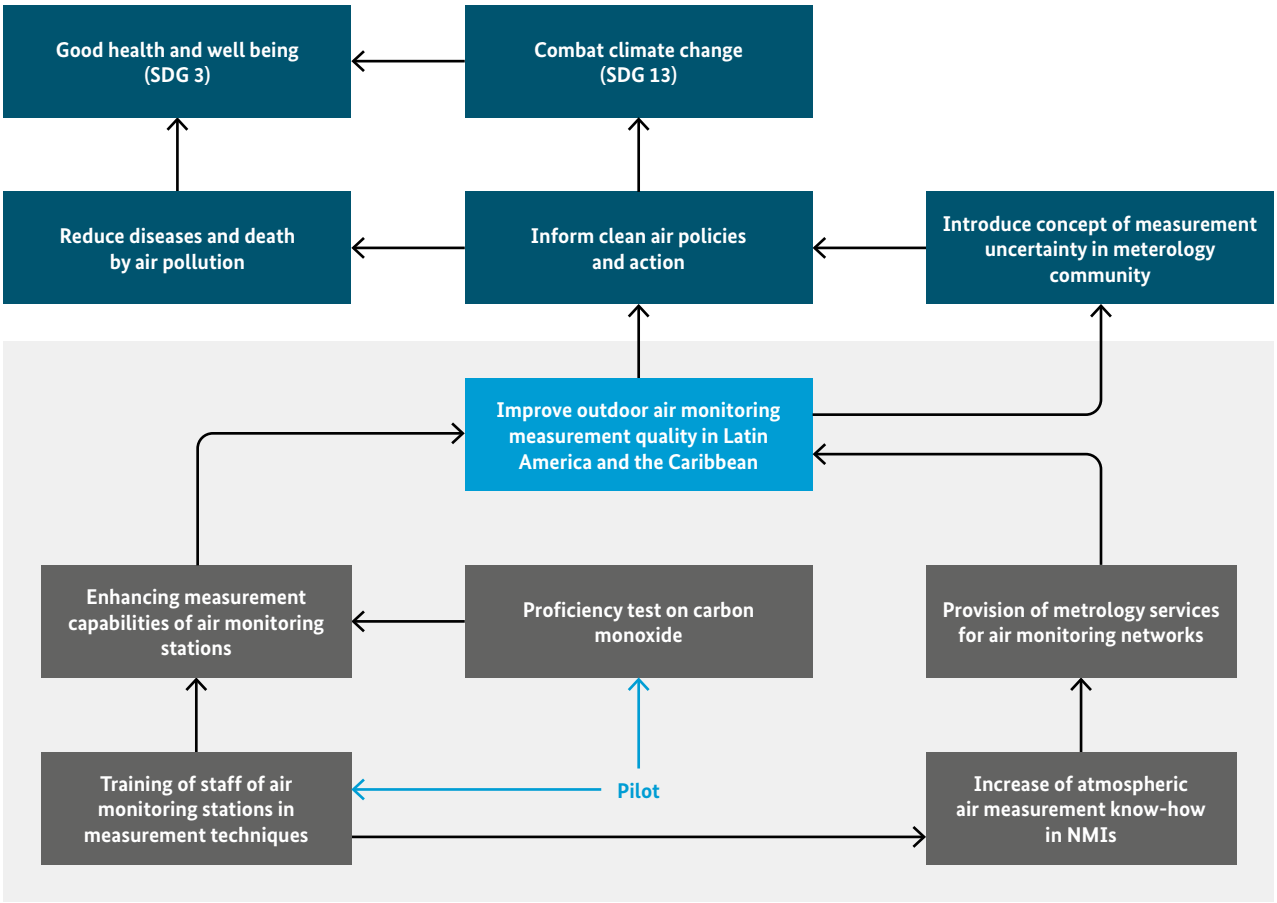

Figure 11: QI Impact Chain for Air Monitoring Proficiency Test. Source: Own elaboration.

Main results

"I would like to thank the possibility of participating in the project, it was extremely important to generate links between the metrological institutes and the organisations that carry out air quality measurements, and the possibility of sharing experiences and knowledge between the different networks that participate in the intercomparison. The Project has given us the possibility of continuing to improve the quality certification of our data, since as a laboratory we are in the process of ISO 17025 accreditation and one of the requirements for verifying analytical techniques is the performance of between laboratories and in Argentina we did not have such intercomparisons for air quality.

On the other hand, it allowed us to strengthen the links with INTI, which will enable a greater approach for joint work in order to guarantee the traceability of our patterns and thus improve the quality of our data.

And finally, it allowed us to make connections with other countries in order to make a mutual collaboration on air quality issues."

María Inés de Casas, Deputy Operational Manager
of the Automatic Atmospheric Monitoring Network in the
Government of the City of Buenos Aires/ Argentina

1. Implemented proficiency test (based on ISO 17043) on carbon-monoxide, a key pollutant in the atmosphere.

2. Creation of an informal regional network for outdoor air monitoring with the participation of the National Metrology Institutes in the region.

3. Strengthened expertise of National Metrology Institutes about the needs of outdoor air monitoring networks in the region.

Lessons learnt

- The measurements of the outdoor air monitoring networks are frequently not quality assured, so that the data is not meeting validity and reliability criteria.
- The National Metrology Institutes can make a significant contribution through advice and services to improve the results of atmospheric air monitoring and enhance the comparability of the produced data.
- The project identified the knowledge and service needs.

Outlook

- The intercomparison was based solely on carbon monoxide (CO). In the future, further chemical pollutants need to be addressed, e.g. lead, nitrogen oxide, ozone, particulate matter, carbon dioxide, and sulphur dioxides.
- The cooperation in the area of air pollution control between NMIs, Air monitoring Networks and Ministries of Environment should be deepened as air quality is a cross cutting topic.
- The concept of uncertainty of measurement as well as the benefits of meteorological services should be anchored in the air quality measurement community in order to improve the validity and reliability of air quality data.

4.4.2. Cost-Effective Air Quality Measuring Instruments

Testimonial

"The cooperation with the PTB, the National Metrology Institutes, the Air Monitoring networks, and the Ministries for Environment has significantly catalysed the interest in the application of affordable air quality measurement systems in Latin America."

Sean Khan, Coordinator of UN Environment's Global Environmental Monitoring System Unit (GEMS/Air)

Context

Although air quality of urban areas is a key item on the political agenda, the air quality monitoring networks are currently sparsely deployed in Latin America and the Caribbean. One main reason for this is that traditional real-time air quality monitoring instruments are expensive to install and maintain. However, more affordable sensors have been developed, recently. UN Environment is offering support to developing countries in designing and setting up air quality monitoring networks, using low cost devices as a compliment to traditional monitoring instruments.

Nevertheless, it needs to be ensured that these new measurement devices meet the quality criteria for official data. Therefore, the appropriate performance of the devices in the context of Latin American and Caribbean environmental conditions has to be verified and the devices have to be calibrated to ensure confident data for the monitoring of the air quality. However, some of these necessary calibration services are not yet being offered in Latin America and the Caribbean. To start to raise awareness for this need of services provided by quality infrastructure (QI) and to develop these services, PTB and its regional partners – in particular the Interamerican System of Metrology (SIM) – have cooperated with UN Environment Programme.

PTB and its partners bring in their metrology competences to guarantee the reliability of the data produced by these new technologies and therefore to empower the countries to expand their environmental monitoring capabilities in a cost-effective manner. This also can lead to an improved spatial coverage of air quality measurements.

Main results

"The cooperation with the PTB, the National Metrology Institutes, the Air Monitoring networks and the Ministries for Environment has significantly catalysed interest in low cost air quality measurement systems in Latin America and other regions of the world such as Africa. The collaboration has inspired and facilitated interest from other countries to validate the performance and applicability of low-cost sensors for air quality management. In turn, the multi-stakeholder approach has led to interest from donors and an evolution of the collaboration mechanism from, for example, the US Embassy overseas missions that have air quality monitors that will be used for colocation studies. In LAC, Peru has joined the effort to validate the performance of low-cost sensors in 2019 with additional countries such as Guatemala and Columbia planned for 2020.

Cost-Effective Air Quality Measuring Pilot

Objectives	Develop calibration services for cost-effective air monitoring devices (provided by a UN Environment's Global Environmental Monitoring System Unit) and identify the potential for innovation together with metrology institutes
Duration	From August 2017 to July 2019
Participants	UN Environment Global Environmental Monitoring System Unit; Argentina (INTI, APrA Buenos Aires, Nacional Air Monitoring Network, Ministry of Environment) and Costa Rica (Univ. Nacional, USAC and LACOMET, MINAE), Guatemala (SNC and INSIVUMEH) as pilot countries
Main activities implemented	1. Kick-off workshop in Buenos Aires in May 2018 2. Installation of cost-effective sensors in air monitoring stations in Buenos Aires (March 2019)

Factsheet 6: Cost-Effective Air Quality Measuring Pilot

QI Impact Chain for Cost-Effective Air Quality Measuring

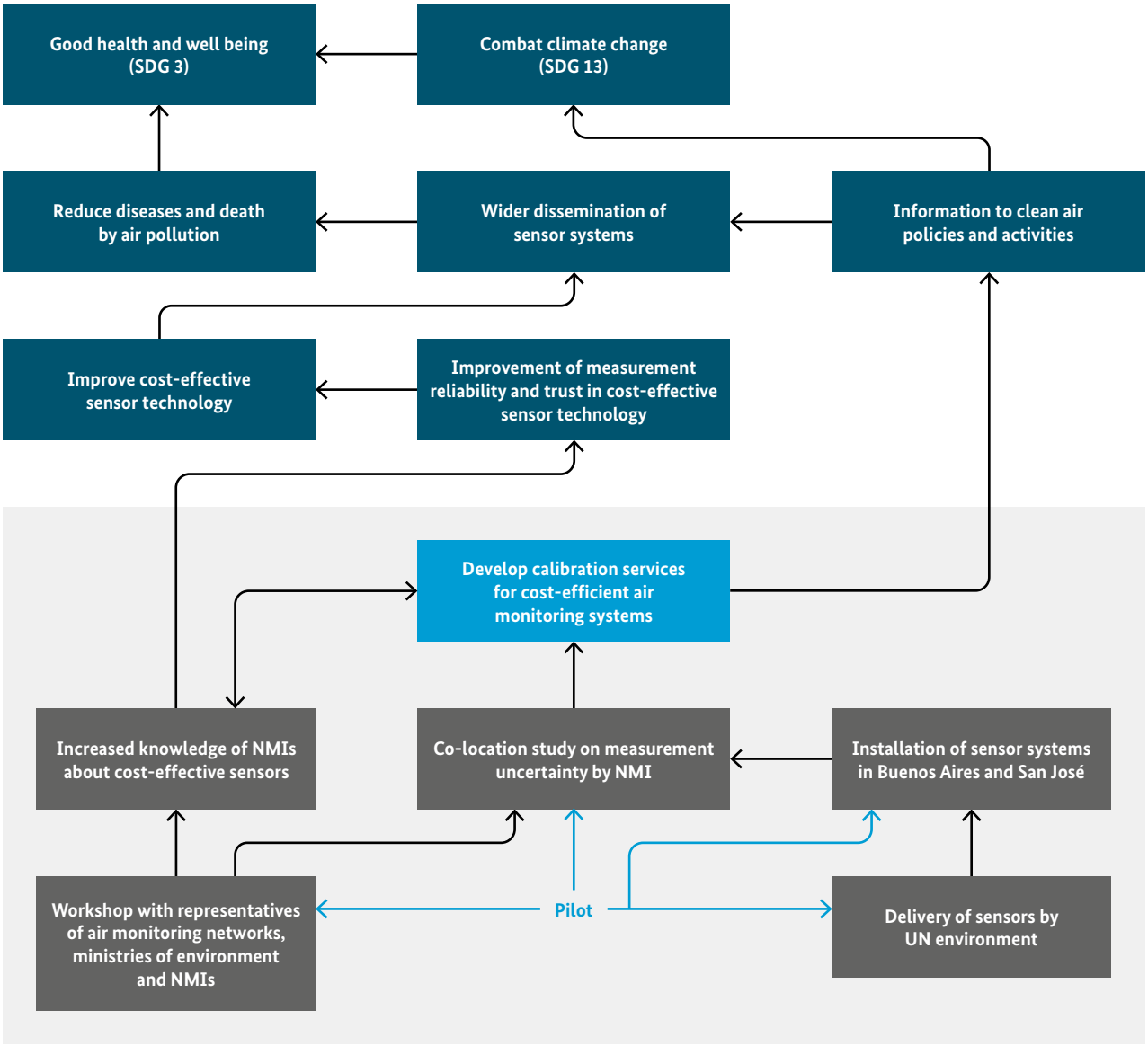

Figure 12: QI Impact Chain for Cost-Effective Air Quality Measuring. Source: Own elaboration.

The PTB collaboration has provided insight on the challenges to be anticipated and a better understanding of how to apply lessons learned to new collaborations, including the development of a centralized but global collaborative platform for air quality management for sensors and traditional measurement instruments."

Sean Khan, Coordinator of UN Environment's Global Environmental Monitoring System Unit (GEMS/Air)

1. Information of air monitoring networks and environmental ministries on the measurement reliability of cost-effective sensor systems.
2. Installation of two sensors in measuring stations in Buenos Aires/Argentina and San José/Costa Rica.
3. Documentation of the experience.

Lessons learnt

- Governments and cities in the LAC region are interested in the introduction of cost-effective sensors.
- It is particularly important to test the operational capability of the sensors under the climatic conditions of Latin America and the Caribbean (e.g. in tropical regions and in the Andes highlands).
- The measurement reliability of cost-effective sensors depends on the climatic conditions on site and the parameter being investigated (e.g. PM, Gases) and require at least one reference instrument to improve reliability of measurements.
- The metrology institutes in the region have so far had no experience with cost-effective sensors for measuring air pollution.

Outlook

- The metrological traceability of the cost-effective sensors needs to be confirmed for all main air pollutants in the case of Latin American and Caribbean countries.
- To ensure the data quality for official purposes, co-locations studies on the uncertainty of the measurement need to be implemented and calibration services for the devices should be developed.
- In the future, the manufacturers and developers of cost-effective sensors should be more closely involved in such project to establish a use case to test suitability (e. g. hotspot identification, health studies, traffic congestion management, etc) and to facilitate logistical planning.
- Low-cost air pollution wireless sensors are emerging in densely distributed networks that provide more spatial resolution than typical traditional systems for monitoring ambient air quality. As data processing and analysis is performed in the cloud, it could be linked to the activities of digitization of metrology 4.0.[50]

50 Metrology 4.0 refers to the support of the measurement science of the implementation of the concept Industry 4.0, see *https://www.ptb.de/cms/fileadmin/internet/forschung_entwicklung/digitalisierung/PTB-Digitalisierungsstudie_2018_EN.pdf* (retrieved July, 8, 2021)

5. Conclusions

The project *Promotion of innovation in the green economy by including quality infrastructure* extends the scope of action of quality infrastructure in sustainable development. The project is in line with the regional strategy of the German Federal Ministry for Economic Cooperation and Development (BMZ) for Latin America and the Caribbean to protect global public goods. It represents an investment in improving the framework conditions for sustainable growth. Strengthening the quality infrastructure for green economy is an equal contribution.

This study was a starting point to explore the relevance of quality infrastructure for transformation to a more sustainable economic model. At the beginning of the project, the green economy stakeholders were not fully aware of the existence and potential of quality infrastructure to support the emergence of more climate-friendly and resource-efficient development. However, during the project, it became clear that, without reliable measurement, a greening of the economy will lack credibility. Metrology and quality infrastructure thus have an essential role to play as a mechanism to build trust and promote acceptance of an economic development that respects planetary boundaries.

This study focuses on Latin America and the Caribbean, although the general discussion is of global relevance. The project implementers used a broad and pragmatic understanding of the term green economy and embedded the sustainable development activities in line with the 2030 Agenda Sustainable Development Goals.

A more sustainable development approach is particularly relevant for Latin America and the Caribbean:

- Latin America and the Caribbean are rich in natural resources and biodiversity, have an export surplus of natural resources, and suffer overexploitation.
- Latin America and the Caribbean is still the world's most unequal region, and its economic growth remains low.
- Latin America and the Caribbean is the most urbanised region in the world.

The study has shown that the field of green economy is still new for the institutions of the national quality infrastructure. In recent decades, many new environmental services have been created, which is an excellent entry point for becoming a recognised service provider with a broader green growth strategy. The emergence of a greener economy is an opportunity for the quality infrastructure to expand their services and create new ones. However, supply and demand for this type of quality infrastructure services will not evolve quickly due to various kinds of market failure (i. e. indivisibility, information asymmetry, externalities). Meso-Institutions must, therefore, overcome this kind of chicken-and-egg problem and support the appropriate service development. Given the novelty of the green economy, it will be an explorative process, and the development of specific services needs to be context-specific.

The public sector is vital for the creation of new quality infrastructure services for the green economy. As a regulator, the state establishes the game rules and creates incentives to invest in green technologies. Sustainable public procurement is another instrument to increase demand for green products and services, creating critical mass and tipping points for green transformation. The state itself must also invest in quality infrastructure services and provide them as public goods.

The exploration of different areas of the green economy has shown that in many, if not all, sectors of the economy, we see a trend towards more sustainable production. Furthermore, the increase in sustainability certification – regarding protecting the environment or social goals – has established several niche markets and already affects mainstream markets.

The success of labelling schemes will depend on consumer trust. If quality infrastructure does not support consumers' choice for sustainable products and services, the whole system will be damaged. Therefore, the role of quality infrastructure services is critical to guarantee long term dynamics through trustworthy conformity assessment by independent and internationally recognised third

parties. Private sustainability schemes need to become integrated into the formal quality infrastructure system.

The examples of the second part of the study have shown various concrete entry points for quality infrastructure into the green economy. Examples from multiple economic sectors show the thematic breadth of the green economy. Each industry has specific requirements and demands on the quality infrastructure. Therefore, quality infrastructure organisations need to tailor their services to sectoral needs. At the same time, limited project funds require thematic selection. The necessary depth of intervention is only achieved by prioritisation.

The evaluation of the project confirms that the project is highly relevant for the executing institutions of the quality infrastructure (Ruth and Scarioni, 2019). The relevance is shown by the great interest of the project partners in strengthening their capacities in proficiency tests, forums and technical support. These offers of the project enabled them to get closer to the actors of the green economy, to identify demand, and develop better or new services for the green economy. Furthermore, the pilot interventions served as good examples and contributed to the improvement of quality infrastructure and its green economy-related services. Thus, the project helped introduce a green economy and the concept of sustainable development into quality infrastructure institutions and facilitate institutional change.

The project evaluation confirmed that the implementation of the pilot projects made it possible to raise awareness among green economy actors and identify the intersection between the strategic interests of partner institutions and the demand for quality infrastructure services in the green economic sector. The evaluators' highlight that the project supports the consolidation of several learning processes. The training courses and workshops helped to disseminate technical knowledge in the institutions. Various project activities strengthened the exchange of experience and learning between the partner institutions. Another learning is the sharing of responsibilities with the partners who learned during the implementation of the project. The decentralised structure of the regional project and the high commitment of the actors in the pilot projects implied empowerment of the institutions.

Annexes

Annex 1 – Green Economy Priorities in Selected Countries

Country	Green economy priorities
Argentina *	Argentina rejected the green economy as a neoliberal concept still during the Rio+20 Earth Summit.[51] Under the government of Mauricio Macri, Argentina was more open to the concept and seemed to be involved in international programs and activities. The experience related to a more environmentally friendly traffic in the city of Buenos Aires (metrobus and promotion of bicycles) is an important reference for a new policy. Major problems are the contamination of rivers and the environmental impacts of the mining industry. Energy policy, previously focused strongly on fossil fuels, is now showing the rise of new incentives for renewable energies. Agriculture is highly industrialized and genetically modified soybean production is still the backbone of the Argentinean export economy. In 2015, Argentina exported soya for a value of 3.8 billion US-$ compared to around 500 million US$ in bovine meat exports (International Trade Centre ITC, *www.trademap.org*). Argentina has demonstrated a strong commitment to sustainability in the context of international processes and has a clear interest in pursuing economic, social and environmental objectives in an integrated manner. Argentina joined PAGE in 2018, which coincided with its Presidency of the Group of Twenty.[52]
Barbados	Barbados is as a small island economy strongly exposed to climate change. Cost protection and climate mitigation is high on the political agenda. At the same time Barbados has developed a relatively strong indigenous solar industry (Rogers 2016). The Government of Barbados has made strong policy and institutional commitments to sustainable development, for instance through long and medium-term strategic frameworks, a Social Compact with the private sector and trade unions, and a National Sustainable Development Policy. Its National Strategic Plan (2006–2025) (NSP) provides a framework for Barbados for becoming a fully developed society that is prosperous, socially just and globally competitive. The Plan advances six strategic goals in pursuit of the national vision for 2025. Goal four of the NSP speaks specifically of *Building a Green Economy: Strengthening the Physical Infrastructure and Preserving the Environment*.[53] Ever since the creation of the NSP, an inclusive green economy (IGE) as a development priority has remained despite changes in administration. Specifically, the current administration has been articulating its commitment to IGE in the context of a *blue economy* (defined by the World Bank as the *sustainable use of ocean resources for economic growth, improved livelihoods and jobs, while preserving the health of ocean ecosystem*).
Bolivia *	Bolivia is one of the protagonists of a concept inspired by the indigenous worldview (cosmovisión) of living well (vivir bien). The country is rich in natural resources and promotes nationalized extractivism strongly, which generates conflicts with environmental objectives (Acosta and Martínez 2009, Acosta 2011). The concept of Good living was designed as an alternative paradigm and critique to the green economy model.

Continued on next page

51 *http://www.lanacion.com.ar/1483244-la-argentina-no-a-la-economia-verde* (Retrieved 07/04/2020)

52 *https://www.un-page.org/countries/page-countries/argentina* (Retrieved 07/04/2020)

53 *https://www.un-page.org/countries/page-countries/barbados* (Retrieved 07/04/2020)

* Note: In these countries the project has organized a mini workshop which provided key information

Country	Green economy priorities
Brazil	Brazil is the largest country in the region and an integral part of the emerging country group. During the last decade, the country showed remarkable progress in technological innovation and development. Currently the country is affected by a deep economic and political crisis. Because of the importance of the Amazon Rainforest for the world, climate in the country is highly relevant in the international debate about environmental protection and green development. The State Mato Grosso joined in the year 2016 the PAGE initiative.[54] The State government has committed to and invested in the transformation of the current development model into one that causes less environmental damage and increases social equity. In 2015, it launched the strategy – Produce, Conserve and Include (PCI), with the objective to increase production, conserve natural resources such as forests and promote the inclusion of families in rural settlements as well as traditional and vulnerable communities. This strategy complements various national level planning instruments advancing sustainable development across Brazil, including the Action Plan for the Prevention and Control of Deforestation in the Amazon, the National Climate Change Policy (NCCP), and the Low Carbon Agriculture Plan, a sectoral plan of the NCCP. The government of the state of Mato Grosso has determined that the key priority for PAGE support is the development of a green economy model with an emphasis on the generation of green employment opportunities and poverty eradication as well as the identification and development of opportunities and capacities in different sectors of sustainable technology.
Chile	Chile is one of the countries with higher economic development in Latin America.[55] The country's GDP has more than doubled in the last 20 years, which has helped to improve the quality of life of its citizens. In recent years there has been a major concern of both the public and private sector for reducing the negative impact on the environment. Chile faces environmental challenges including air pollution, soil contamination, climate change, waste, threats to biodiversity, water shortage and water contamination. In Chile, the green growth concept is barely known and also, sometimes, is misunderstood. Some private and public actors consider the path to green growth only as an issue about cost, that is, they have a negative approach to this concept. The opinion that this concept can also imply opportunities is still raw in many people's minds. Chile has initiated some steps on the road to green growth in the context of sustainable development and the boosting of green innovation. Chile's continued green growth strategy should be based then in a scheme with three key pillars: 1. Sustainability sectorial strategies: sustainable mining, sustainable tourism, sustainable construction, sustainable agriculture, etc. 2. Economic instruments and other complementary mechanisms: extended producer responsibility, tradable emissions permits, voluntary agreements, fuel taxation, green public procurement, eco-labeling, tradable fishing quotas, tradable water rights, etc. 3. Innovation: Cross-sector environmental technology, energy efficiency and renewable energies, etc.

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54 *https://www.un-page.org/countries/page-countries/brazil-mato-grosso-state* (Retrieved 07/04/2020)

55 This description is based on MARTINEZ-FERNANDEZ, C., SHARPE, S., WOISCHNIK & ALWINE DE LA MAZA, C. 2014. Chile´s Pathway to Green Growth: Measuring progress at local level. In: OECD LOCAL ECONOMIC AND EMPLOYMENT DEVELOPMENT (LEED) (ed.). Paris.

* Note: In these countries the project has organized a mini workshop which provided key information

Country	Green economy priorities
Colombia	The Government of Colombia has identified green growth as critical to maintaining development in the years to come and has made it a priority to implement inclusive and environmentally sustainable growth principles into the country's development planning.[56] The Government of Colombia has established green growth as a key framework for economic development. The National Planning Department (DNP) implements the Green Growth Plan project, which includes: ■ Mainstreaming green growth into the DNP's National Development Plan 2014-18 ■ Supporting technical teams in the DNP's Energy, Transport and Agricultural sectors to scope, analysis and propose green growth objectives ■ Developing sector-specific green growth indicators and implementation strategies within the National Development Plan ■ Supporting the formulation of a long-term green growth policy for Colombia The overall objectives of this project are to establish green growth as a key element within Colombia's National Development Plan 2014–2018, build green growth institutional and human resource capacity within Colombia's National Planning Department, support implementation of green growth as per the targets set for the 2014–2018 period and support in the establishment of a long-term vision of green growth for Colombia.
Costa Rica *	Costa Rica has positioned itself as a forerunner of green and peaceful development. It has a successful history in forest conservation, managing to revert its deforestation rates through innovative policy in the form of Payment for Environmental Services. Its recent declaration to become CO_2-neutral until 2021 and its national program and label for C-Neutral companies and enterprises are a strong confirmation to renewing its green leadership. On the other hand, Costa Rica suffers from an overuse of chemical fertilizers and pesticides for its main agricultural crops, such as bananas and pineapples). Traffic congestion in the metropolitan area of San José is also one of the country's main challenges and a major source of GHG emissions. Also, the political system faces significant operational problems, limiting the possibilities of adequately facing the challenges of a green transformation. (Ilmi Granoff, Monica Araya et al. 2015)
Guyana	Guyana is developing a long-term Green State Development Strategy (15–20 year planning) with the support of PAGE, building on previous national commitments to sustainable development, such as: the country's National Determined Contribution (NDC), the Low Carbon Development Strategy, the Climate Resilience Strategy Action Plan (CRSAP), the Renewable Energy Transition Plan, the Climate Change Resilience Strategy and Adaptation Plan, the National Strategy for Biodiversity Conservation, and the National Adaptation Strategy for the Agricultural Sector (2009–2018). This Strategy lays the principle foundations for inclusive green economic and social growth, provides a roadmap for achieving sustainable development goals and related targets, and outlines a long-term vision for a prosperous and equitable future.[57] The objective of the strategy is to reorient and diversify Guyana's economy, reducing reliance on traditional sectors and opening up new sustainable income and investment opportunities in higher value adding and higher growth sectors, while promoting an equitable distribution of benefits to all.
Mexico *	Mexico is one of the founding countries of the Global Green Growth Institute and has promoted this mode of development since the launch of the Green Growth Knowledge Platform in the country in 2012. In 2019, The Mexican government has joined an international initiative called *Partnering for Green Growth and the Global Goals 2030* (P4G) to spur sustainable economic growth. Mexico is eager to advance green growth priorities focusing on issues that directly affect greater Mexican concerns such as agriculture and food loss and waste efforts, efficient energy and electric mobility. Mexico will engage with innovative P4G partnerships to involve the private sector in sustainable issues and connect them with national policy such the National Plan for Electric Energy from the National Development Plan 2019–2024 and the National Strategy of Electric Mobility by SEMARNAT.[58]

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56 *https://www.greengrowthknowledge.org/project/gggi-colombia-green-growth-plan* (Retrieved 07/04/2020)

57 *https://www.un-page.org/countries/page-countries/guyana* (Retrieved 07/04/2020)

58 *https://p4gpartnerships.org/content/mexico* (Retrieved 07/04/2020)

* Note: In these countries the project has organized a mini workshop which provided key information

Country	Green economy priorities
Peru	Peru is one of the most active countries of the region in terms of environmental commitments, which was recognized when it was selected as host of the Climate Change Conference (COP20) in 2014.[59] Peru achieved significant economic growth in the ten years leading to 2014. However, this economic performance is considered unsustainable in the long term because it is based on intensive exploitation of natural resources. The leaving administration has seen green economy as a tool that will guide the country towards sustainable development by reconciling economic development with greater social equity and wealth distribution, while improving efficiency in the use of natural resources. As a result, the Peruvian government requested support from a joint United Nations initiative that helps countries transition to a green economy, PAGE. In late 2013, Peru became the second country to benefit from the PAGE initiative. The overall objective of PAGE in Peru is to integrate the concept of green growth into development policies through the formulation and implementation of inclusive green economy public policy proposals that will promote the efficient use of resources, environmental quality and sustainability and green jobs creation in economic sectors. Peru now receives support from the initiative in four ways: research and knowledge creation; policy dialogue with government officials and important stakeholders; capacity building, education and training; and advisory services on green economy issues.[60]
Uruguay	Uruguay stands out in Latin America for being an egalitarian society, for its high per capita income, and low levels of inequality and poverty. Over the last decades, Uruguay has also made huge transitions to renewable energy generation and lowering its carbon footprint. For instance, during 2017, 70 % of total energy consumption in Uruguay came from renewable sources such as wind and solar energy. The Government of Uruguay is committed to sustainability and green economy in pursuit of higher income, creation of new jobs, poverty reduction, equality and shaping the environment into one of its core pillars of economic development. PAGE is collaborating with the Uruguayan government in the elaboration of the National Development Strategy, a medium-term development plan, and Uruguay 2050, its long-term vision. Uruguay 2050 envisions an acceleration of the economic and social growth experienced over the past decades, with an increased focus on social and cultural inclusion, gender equality, climate change mitigation and adaptation, increased competitiveness and productivity, food security, and advancing a technological revolution, among others. The partnership with PAGE does not only aid in the design of these policies, but also helps improving the planning capacities of the country to seize opportunities, minimize oscillations, and build economic resilience.

59 *http://www.cop20.pe/en/* (Retrieved 07/04/2020)

60 *http://www.un-page.org/greening-perus-economy* (Retrieved 07/04/2020)

* Note: In these countries the project has organized a mini workshop which provided key information

Annex 2 – Alternative Concepts of Sustainable and Green Development [61]

Concept	Definition	Promoters
Circular economy	A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models. (MacArthur 2013)	Ellen MacArthur Foundation
Good living/ Buen vivir	*Buen Vivir* or *Vivir Bien*, are the Spanish words used in Latin America to describe alternatives to development focused on a good life and well-being in a broad sense. The term is actively used by social movements, has become a popular term in some government programs and has even reached its way into the new Constitutions in Ecuador and Bolivia. It is a plural concept with two main entry points. On the one hand, it includes critical reactions to classical Western development theory. On the other hand, it refers to alternatives to development emerging from indigenous traditions, and in this sense the concept explores possibilities beyond the modern Eurocentric tradition. (Acosta and Martínez 2009, Vanhulst and Beling 2012, Balanza 2013, de Jaramillo 2014)	Ecuador/Bolivia
Green economy	UN Environment defines a green economy as one *that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive.* (UNEP 2011, UNEP 2015)	UN Environment
Green growth	Green growth means fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. (Dercon 2012, OECD, THE WORLD BANK et al. 2012)	OECD/Worldbank
Green industry	If we want a sustainable and economically viable future, we need to ensure our industry does not harm the environment. We call this green industry. (UNIDO 2009)	UNIDO
Low carbon Economy	A low-carbon economy (LCE), low-fossil-fuel economy (LFFE), or decarbonised economy is an economy based on low carbon power sources that therefore has a minimal output of greenhouse gas (GHG) emissions into the environment biosphere, specifically CO_2 as a result of human activity (Carrasco 2014).	Intergovernmental Panel on Climate Change (IPCC), UN-FCCC, major consultancy firms
Sustainable development	The Brundtland Report's definition *development which meets the needs of the present without compromising the ability of future generations to meet their own needs.* [62]	UN
Green value chains	Green value chain development is a systemic approach integrating environmental support functions, environmental rules and regulations and market players in greening the value chain. It transforms the conventional linear view of value chains into a cyclical system view in which value chains operate in the natural environment on which they depend and which they also affect. [63] (Tan and Zailani 2009)	FAO/OECD

61 Without reference to the debate in Latin America and the Caribbean there is a previous intent to present different concepts of Sustainable Development: SCHMITZ, H. & BECKER, B. 2013. From Sustainable Development to the Green Transformation – A Rough Guide. Institute of Development Studies Briefing Paper.

62 *http://www.un-documents.net/wced-ocf.htm* (Retrieved 20/04/2020)

63 *http://www.enterprise-development.org/wp-content/uploads/Green_Value_Chains_to_Promote_Green_Growth.pdf* (Retrieved 20/04/2020)

References

ABOAL, D., ARIAS-ORTIZ, E., CRESPI, G., GARDA, P., RASTELETTI, A., RUBALCAVA, L., VAIRO, M. & VARGAS, F. 2015. La innovación y la nueva economía de servicios en América Latina y el Caribe: Retos e implicaciones de política. In: INTERAMERICAN DEVELOMENT BANK, I. (ed.). Washington DC.

ACOSTA, A. 2011. Extractivismo y neo extractivismo: dos caras de la misma maldición. Revista Línea de Fuego.

ACOSTA, A. & MARTÍNEZ, E. 2009. El buen vivir. Una vía para el desarrollo, Quito.

AGARWAL, R., BAJADA, C., GREEN, R. & LO, E. 2017. Economic Value of NATA Accreditation to Australia. In: SYDNEY, U. O. T. (ed.). Sydney.

ALTENBURG, T. 2010. Building inclusive innovation systems in developing countries: challenges for IS research. Handbook of innovation systems and developing countries: building domestic capabilities in a global setting, pp. 33–56.

BARBIER, E. B. & MARKANDYA, A. 2013. A new blueprint for a green economy, Routledge.

BIPM, I., IFCC, I., ISO, I. & IUPAP, O. 2008. International Vocabulary of Metrology–Basic and General Concepts and Associated Terms, 2008. JCGM, 200, 99–12.

BUITRAGO RESTREPO, P. F. & DUQUE MÁRQUEZ, I. 2013. The Orange Economy: An Infinite Opportunity, Washington D.C., Interamerican Development Bank (IDB).

CASABURI, G., CRESPI, G., DE LEÓN, I. L., FERNÁNDEZ, J., FIGAL GARONE, L., GRAZZI, M., GUAIPATÍN, C., KATZ, J., LLISTERRI, J. J. & MAFFIOLI, A. 2016. La política de innovación en América Latina y el Caribe: Nuevos caminos.

CEPAL 2016. Horizontes 2030 – Igualdad en el centro del desarrollo sostenible. Ciudad de Mexico.

CUNNINGHAM, S. 2009. The role of market failure in the utilisation of quality management services by the tooling industry. Potchefstroom/South Africa.

FAGERBERG, J. 2005. Innovation: a guide to the literature. In: FAGERBERG, J., MOWERY, D. C. & NELSON, R. R. (eds.) The Oxford Handbook of Innovation. Oxford and New York: Oxford University Press.

FERREIRA, F. H., MESSINA, J., RIGOLINI, J., LÓPEZ-CALVA, L.-F., LUGO, M. A., VAKIS, R. & LÓ, L. F. 2012. Economic mobility and the rise of the Latin American middle class, World Bank Publications.

FREEMAN, C. 1995. The 'National System of Innovation'in historical perspective. Cambridge Journal of economics, 19, 5–24.

FRENZ, M. & LAMBERT, R. 2012. Innovation dynamics and the role of infrastructure.

FRENZ, M. & LAMBERT, R. 2014. The economics of accreditation. NCSLI Measure, 9, 42–50.

FUNDACIÓN BARILOCHE 1976. Modelo mundial latinoamericano. Nueva Sociedad, 22, 16–29.

GEREFFI, G. 2018. Global Value Chains and Development: Redefining the Contours of 21st Century Capitalism, Cambridge/ UK, Cambridge University Press.

GEREFFI, G., HUMPHREY, J., KAPLINSKY, R. & STURGEON*, T. J. 2001. Introduction: Globalisation, value chains and development. IDS bulletin, 32, 1–8.

HARMES-LIEDTKE, U. 2010. The Relevance of Quality Infrastructure to Promote Innovation Systems in Developing Countries. Braunschweig: PTB.

HERRERA, A. O. 2004. Catastrofe o Nueva Sociedad?: Modelo Mundial Latinoamericano-30 Años Después, IDRC.

HIDALGO, C. A. & HAUSMANN, R. 2009. The building blocks of economic complexity. Proceedings of the National Academy of Sciences, 106, 10570–10575.

ISO 2011. International standards and Private Standards. Paris.

JACKSON, T. 2009. Prosperity Without Growth. Economics for a Finite Planet. London (Earthscan) 2009.

KELMAN, I. 2014. No change from climate change: vulnerability and small island developing states. The Geographical Journal, 180, 120-129.

KENIS, A. & LIEVENS, M. 2015. Limits of the Green Economy, Taylor & Francis.

LEDERMAN, D., MESSINA, J., PIENKNAGURA, S. & RIGOLINI, J. 2013. Latin American entrepreneurs: Many firms but little innovation, World Bank Publications.

LUNDVALL, B.-A. 1992. National innovation system: towards a theory of innovation and interactive learning. Pinter, London.

LÜTKENHORST, W. 2016. Industrial Policy for Sustainable Development – New Conceptual Perspectives and Insights from Recent European Experience. Bonn: DIE-GDI.

LÜTKENHORST, W., ALTENBURG, T., PEGELS, A. & VIDICAN, G. 2014. Green industrial policy: Managing transformation under uncertainty.

MARIN, A. & STUBRIN, L. 2015. KIBS Associated to Natural Resource Based Industries: Seeds Innovation and Regional Providers of the Technology Services Embodied in Seeds in Argentina and Brazil, 2000–2014. Inter-American Development Bank.

MARTINEZ-FERNANDEZ, C., SHARPE, S., WOISCHNIK & ALWINE DE LA MAZA, C. 2014. Chile's Pathway to Green Growth: Measuring progress at local level. In: OECD LOCAL ECONOMIC AND EMPLOYMENT DEVELOPMENT (LEED) (ed.). Paris.

MAZZUCATO, M. 2015. The entrepreneurial state: Debunking public vs. private sector myths, Anthem Press.

MCDONOUGH, W. & BRAUNGART, M. 2002. Cradle to cradle: Remaking the way we make things, New York, North point press.

MCGUIRE, S. & ISLAM, N. 2015. Indigenous technological capabilities, emerging market firms and the aerospace industry. Technology Analysis & Strategic Management, 27, 739–758.

MEADOWS, D. H., MEADOWS, D. L., RANDERS, J. & BEHRENS, W. W. 1972. The limits to growth. New York, 102.

NAVARRO, J. C., BENAVENTE, J. M. & CRESPI, G. 2016. The New Imperative of Innovation Policy: Perspectives for Latin America and the Caribbean.

NELSON, R. R. 1993. National innovation systems: a comparative analysis, Oxford university press.

OECD, O. F. E. C.-O. A. D. 2005. Oslo Manual, Paris.

PENGUE, W. 2012. Los desafíos de la economía verde. Oportunismo capitalista o realidad sustentable. Colección Ecología. Ediciones Kaikron. Buenos Aires.

PIETROBELLI, C. & RABELLOTTI, R. 2011. Global value chains meet innovation systems: are there learning opportunities for developing countries? World development, 39, 1261–1269.

POL, E. & VILLE, S. 2009. Social innovation: buzz word or enduring term? The Journal of Socio-Economics, 38, 878–885.

POTTS, J., LYNCH, M., WILKINGS, A., HUPPE, G., CUNNINGHAM, M. & VOORA, V. 2014. The state of sustainability initiatives review 2014: Standards and the green economy. International Institute for Sustainable Development (IISD) and the International Institute for Environment and Development (IIED).

RIFKIN, J. 2016. How the Third Industrial Revolution Will Create a Green Economy. New Perspectives Quarterly, 33, 6–10.

ROCKSTRÖM, J., STEFFEN, W., NOONE, K., PERSSON, Å., CHAPIN III, F. S., LAMBIN, E., LENTON, T. M., SCHEFFER, M., FOLKE, C. & SCHELLNHUBER, H. J. 2009. Planetary boundaries: exploring the safe operating space for humanity.

RODRIK, D. 2014. Green industrial policy. Oxford Review of Economic Policy, 30, 469–491.

ROGELJ, J., SCHAEFFER, M., MEINSHAUSEN, M., KNUTTI, R., ALCAMO, J., RIAHI, K. & HARE, W. 2015. Zero emission targets as long-term global goals for climate protection. Environmental Research Letters, 10, 105007.

RUTH, P. & SCARIONI, L. 2019. External Evaluation of the Project Promoting Innovation in the Green Economy by Including Quality Infrastructure. Braunschweig: PTB.

SCHMITZ, H. & BECKER, B. 2013. From Sustainable Development to the Green Transformation – A Rough Guide. Institute of Development Studies Briefing Paper.

SCHUMPETER, J. A. 1934. The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle, New Brunswick (U.S.A) and London (U.K.), Transaction publishers.

SCHUMPETER, J. A. 1942. Capitalism, New York, Harper and Brothers.

SWANN, P. 2010. The economics of standardization: an update.

THE WORLD BANK 2008. Global Economic Prospects: Technology Diffusion in the Developing World. Washington.

UN-HABITAT 2012. The State of Latin american and caribbean cities – Towards a new urban transition. Nairobi.

UNCTAD, U. N. C. O. T. A. D. 2007. The Least Developed Countries Report 2007, New York and Geneva.

UNEP 2011. Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. In: PROGRAMME, U. N. E. (ed.). Nairobi.

UNEP 2015. Uncovering pathways towards an inclusive green economy. In: PROGRAMME, U. N. E. (ed.). Nairobi.

UNMÜßIG, B., SACHS, W. & FATHEUER, T. 2016. Critique of the Green Economy: Toward Social and Environmental Equity (2012). The Globalization and Environment Reader, 422.

VIVANCO, D. F., KEMP, R. & VAN DER VOET, E. 2016. How to deal with the rebound effect? A policy-oriented approach. Energy Policy, 94, 114–125.

VON TUNZELMANN, N. & ACHA, V. 2005. Innovation in 'low-tech'industries. The Oxford handbook of innovation, 5, 13.

VON WEIZSÄCKER, E. U., DE LARDEREL, J., HARGROVES, K., HUDSON, C. & SMITH, M. 2014. Decoupling 2: technologies, opportunities and policy options. In: UNEP (ed.).

Abbreviations and Acronyms

4C	Common Code for the Coffee Community
AFNOR	French Standardization Association *(Association française de normalisation)*
ASM	Artisanal and Small-Scale Mining
BAU	Business as Usual
BMZ	Federal Ministry for Economic Cooperation and Development *(Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung)*
BREF	Best Available Techniques Reference Document
C	Celsius
CO	Carbon Monoxide
CO2	Carbon Dioxide
CBD	United Nations Convention on Biological Diversity
CCC	Clean Clothes Campaign
CMCs	Calibration and Measurement Capabilities
COMCYT	Inter-American Committee on Science and Technology
COP	Conference of the Parties
COPANT	Pan American Standards Commission
CP	Cleaner Production
CWA	Clean Water Act
DTRIC	Regional Programme for Rural Territorial Development with Cultural Identity *(Programa Regional de Desarrollo Territorial Rural con Identidad Cultural)*
ECLAC	United Nations Economic Commission for Latin America and the Caribbean
EDGE	Excellence in Design for Greater Efficiencies
EPD	Environmental Product Declaration
ETI	Ethical Trading Initiative
FLA	Fair Labour Association
FLO	Fairtrade Labelling Organization
FWF	Fair Wear Foundation
GCET	Global Code of Ethics for Tourism
GDP	Gross Domestic Product
GE	Green Economy
GEF	Global Environmental Facility
GEMS/Air	Global Environmental Monitoring System Unit
GGGI	Global Green Growth Institute
GGKP	Green Growth Knowledge Platform
GHG	Greenhouse Gas Emissions
GVC	Global Value Chain
HWM	Hazardous Waste Management
IAAC	Inter-American Accreditation Cooperation
IATA	International Air Transport Association
ICT(s)	Information and Communication Technologies
IFC	International Finance Corporation
IFOAM	International Foundation for Organic Agriculture
ILO	International Labour Organization

IWA	International Workshop Agreements
INTI	*Instituto Nacional de Tecnología Industrial*
IoT	Internet of Things
ISO	International Organization for Standardization
ITC	International Trade Centre
KIBS	Knowledge Intensive Business Services
LAC	Latin America and the Caribbean
LCA	Life Cycle Assessment
LCE	Low Carbon Economy
LEED	Leadership in Energy and Environmental Design
LIC	Low Income Counties
LMT	Low and Medium Tech Industries
MAG	Ministry of Agriculture and Livestock *(Ministerio de Agricultura y Ganadería)*
MIC	Middle Income Countries
MSTQ	Metrology, Standards, Testing and Quality Assurance
NCPC	National Cleaner Production Centres
NGO	Non-governmental Organization
NIS	National Innovation System
OAS	Organization of American States
OECD	Organization for Economic Cooperation and Development
QICA	Quality Infrastructure Council for the Americas
OPC	Ordinary Portland Cement
PAGE	Partnership for Action on Green Economy
PCR	Product Category Rules
PT	Proficiency Test
PTB	Federal Institute of Physics and Technology *(Physikalisch-Technische Bundesanstalt)*
QI	Quality Infrastructure
R&D	Research and Development
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
RSL	Restricted Substance List
SAI	Social Accountability International
SAN	Sustainable Agriculture Network
SDGs	Sustainable Development Goals
SENASA	*Servicio Nacional de Sanidad y Calidad Agroalimentaria*
SIM	Inter-American Metrology System
SRI	Sustainable Recycling Industries
STI	Science, Technology and Innovation
TBT	Technical Barriers to Trade
TC	Technical Committee
TGVC	Textile and Garment Value Chain
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development

UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
UNITAR	United Nations Institute for Training and Research
WF	Water Footprint
VC	Value Chain
WBCSD	World Business Council for Sustainable Development
WEEE	Waste Electrical and Electronic Equipment
WMR	Waste Management and Recycling
WRF	World Resources Forum
WRI	World Resources Institute
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization

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Imprint

Published by
Physikalisch-Technische Bundesanstalt
Bundesallee 100
38116 Braunschweig
Germany

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Title image
© iStock

As of July 2021

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