Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
National Metrology Institute

INTERNATIONAL COOPERATION

Quality Infrastructure and Climate Change in Latin America and the Caribbean

Niels Ferdinand
Katharina Telfser

german cooperation
DEUTSCHE ZUSAMMENARBEIT

The authors

Niels Ferdinand is a founder and director of BSD Spain. BSD Consulting – business. sustainability. development – is a global sustainability consultancy that provides thought leadership and customized solutions for the management of sustainability issues to international business and governmental organizations. Through our local offices and partner organizations, BSD is able to provide local expertise in all geographical regions. It is BSD's aim to create the strongest possible impact in sustainable development through innovation and excellence. Over the past 20 years, Niels has directed numerous consultancy projects for multinational companies in Europe, Asia, Latin America and Africa. His focus areas are sustainability communication, stakeholder engagement, environmental management, sustainable supply chain management, social standards and the implementation of sustainability strategies. Since 1998, he has worked as an international expert in developing countries on behalf of PTB focusing on the services of the national quality infrastructure needed for renewable energies, climate change monitoring, value chains as well as water and environmental management. For PTB, he has also directed studies on quality criteria in financing photovoltaic projects and on quality infrastructure for climate protection.

Katharina Telfser has an international background in economics and sustainability. Working as a Junior Consultant at the BSD Spain office, she is involved in projects on sustainability communication, impact assessment and sustainability development with a specific focus on quality infrastructure. She is involved in PTB projects focusing on renewable energies and agriculture and has supported PTB activities in regional cooperation, mining, and drinking water. Katharina has co-authored studies on quality criteria in financing photovoltaic projects and quality infrastructure for climate protection, as well as assessments of national quality infrastructure.

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Preface

This study was carried out within the framework of the *Regional Fund Quality Infrastructure for Biodiversity and Climate Protection in Latin America and the Caribbean*, starting in 2014. Its objective is to strengthen the capabilities of the quality infrastructure (QI) institutions in Latin America and the Caribbean in order to develop and supply new and innovative services in the fields of biodiversity and climate protection.

The project has a fund structure, which provides an optimum gearing of the support measures to the different national and sub-regional framework conditions. National and regional QI institutions submit joint project proposals with respect to biodiversity and climate protection. These are assessed and selected by a Project Steering Committee (PSC) according to well-defined criteria. This structure allows the different needs of the QI institutions to be addressed with the necessary flexibility, the implementation of trendsetting projects exemplarily and the strengthening of different QI elements, both in individual countries and in the region.

The project is implemented by the Working Group for International Cooperation for Latin America and the Caribbean of the Physikalisch-Technische Bundesanstalt (PTB). The political partner is the Organization of American States (OAS). The regional organizations of standardization (Pan American Standards Commission, COPANT), metrology (Inter-american Metrology System, SIM) and accreditation (Inter American Accreditation Cooperation, IAAC) and their member organizations are directly involved in the implementation of the project. Representatives from regional organizations form part of the PSC.

This study examines which QI services can contribute to generating information, monitoring, and managing variables relevant for climate change mitigation efforts. It presents potentialities, chances and good examples of QI development in Latin America and the Caribbean. It was written by Niels Ferdinand and Katharina Telfser, and revised by the PSC members consisting of representatives from OAS, SIM, COPANT, IAAC and PTB.

PTB's International Cooperation

The Physikalisch-Technische Bundesanstalt (PTB) is the National Metrology Institute of Germany and the highest authority for accurate and precise measurements in Germany. For more than 50 years, PTB has shared its core competence in international development cooperation, mainly funded by the Ministry for Economic Cooperation and Development (BMZ). In this context, PTB supports developing and emerging economies in the comprehensive field of quality infrastructure. The ultimate objective of PTB's International Cooperation department is to contribute to sustainable economic, social and ecological development.

1. Executive summary

Quality infrastructure is key in the context of climate change in Latin America and the Caribbean.

In worldwide comparisons, Latin America and the Caribbean are amongst the least greenhouse-gas-emitting regions. However, given the rich biodiversity, the concentration of human settlements in coastal areas, and the importance of agriculture, the region is exposed to high risks because of climate change. A well-functioning quality infrastructure is essential to monitor climate change correctly and generate the information needed for decision-making and for taking adequate measures.

Links between quality infrastructure services and climate change are not seen holistically nor supported systematically.

So far, the approach to developing quality infrastructure for climate protection in the region has not been systematic. In some areas, like standardization and certification, quality infrastructure services are already far more advanced than in others. In metrology, for instance, many variables related to climate change have traditionally been in the realm of meteorology and the cooperation between metrology and meteorology is still very limited. A national quality infrastructure can only contribute fully to climate protection if it is developed as a whole.

Existing national initiatives are important examples for other countries.

In some Latin American countries, quality infrastructure services with relevance for climate protection are already being developed. In Mexico, for example, the National Metrology Institute is developing secondary capabilities for greenhouse gas emission measurements, several relevant international standards have been adopted by the National Standards Body and specific accreditation for conformity assessment bodies is available. Brazil and Costa Rica are also very advanced in this area. In other Latin American countries, similar initiatives exist. Such pioneering initiatives in one or more areas of the quality infrastructure are important examples for other countries in the region.

Greenhouse gas emissions are a focus area for quality infrastructure development in the region.

Leading countries in Latin America have already developed a number of services in the area of greenhouse gas emissions and other countries have shown considerable interest in developing the necessary quality infrastructure services nationally. Due to the importance of greenhouse gas emissions globally, further development of the relevant services, especially in metrology and testing, is needed in Latin America and the Caribbean.

Climate variables that could serve as a basis for renewable energy development and related quality infrastructure are not yet in the focus in Latin America and the Caribbean.

So far, the development of quality infrastructure services related to wind speed and wind direction has been limited. Solar irradiance is increasingly being addressed by some national metrology institutes of the region in the framework of the Inter-american Metrology System (SIM), in cooperation with the corresponding meteorology institutes. These variables are important both for climate change monitoring, and as a basis for the development of renewable energies. The relatively slow development of these monitoring mechanisms might be related to the still limited importance of renewable energies, such as wind and solar, in most Latin American and Caribbean countries. However, investments in renewable energies in Latin America and the Caribbean reflected the global growth trend, peaking at USD 17 billion in 2015 before falling to USD 9 billion in 2016. Given the considerable potential of those technologies in the region, renewable energies are gaining importance by the day.[1] Quality infrastructure has an important role in supporting the generation of reliable information and the viability of these new technologies in general, as national targets and investors' expectations can only be met if the quality and safety of the installed technologies is ensured.

1 PTB is supporting the strengthening of quality infrastructure for the energy sector in Latin America and the Caribbean in the regional project "Quality Infrastructure for Energy Efficiency and Renewable Energy". For more information, please consult the project information sheet: https://www.ptb.de/cms/fileadmin/internet/fachabteilungen/abteilung_9/9.3_internationale_zusammenarbeit/projektprofile/PTB_project_LAC_Energy_95309_EN.pdf

Variables to monitor land use change and to provide information on related decisions are not covered by quality infrastructure.

Land use change, and particularly the conversion from forest to pastures and croplands, is one of the main sources of greenhouse gas emissions. While sufficient and accurate data about changes in land use could create a basis for informed decisions in the management of this resource, quality infrastructure services in this area are still rudimentary globally. Internationally, discussions and development initiatives have started, in which Latin American organizations and stakeholders are involved. Given the importance of the forest areas in Latin America in the climate change context, an involvement of Latin American actors in international discussions about the definition of quality infrastructure services needed in this field is important to monitor land use change and its impacts, to provide the basis for sustainable land use management and to protect both the climate and biodiversity at a global scale.

2. Introduction

Climate change is recognized as one of the major challenges the world is currently facing. According to the World Meteorological Organization (WMO), the year 2015 was the hottest year on record. The global average temperature is estimated to have risen by 0.6 °C (1.1 °F) over the course of the 20th century.[2] Extreme meteorological events are increasing around the globe, with devastating effects especially in the most vulnerable geographic areas and communities.

In an effort to mitigate the effects of climate change, governments around the globe have agreed on measures to be taken to limit atmosphere-altering greenhouse gas (GHG) emissions; targets were set and a number of tools developed. In order for the measures to be successful, action is needed in industrialized and developing countries alike and global cooperation is of the utmost importance.

In the frame of the *Regional Fund Quality Infrastructure for Biodiversity and Climate Protection in Latin America and the Caribbean*, the present study was conducted to clarify the role of quality infrastructure (QI), including metrology, standardization, conformity assessment – testing, inspection and certification – and accreditation,[3] in climate change mitigation with a focus on the region.

The study examines which QI services can contribute to generating information, monitoring, and managing variables relevant for climate change mitigation efforts. It presents potentialities, chances and good examples of QI development in Latin America and the Caribbean.

The target audience of the study are political decision makers, partners of the *Regional Fund Quality Infrastructure for Biodiversity and Climate Protection in Latin America and the Caribbean* and other stakeholders in the areas of QI and climate change in Latin America and beyond. The aim of the study is to raise awareness about the importance of QI in the context of climate change. It provides information for decision-making on the political level and for sensitizing QI actors to climate issues.

Scope

The focus lies on a selection of the essential climate variables defined by the Global Climate Observing System (GCOS) in 2010 (see annex 1). The variables are of physical, chemical or biological nature and are critical for characterizing the Earth's climate. They provide the necessary information to understand and react to climate change. The variables underpin policy assessment and research by the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC).[4] QI services play an important role in ensuring the accuracy and comparability of the generated information.

2 WMO 2016

3 See section 5 for more detailed information about QI

4 Bojinski et al. 2014

As identified in the BMZ position paper for Latin America 2015, the main potential for climate change mitigation in Latin America lies in the areas of energy and environmental protection, including the avoidance of deforestation.[5] Therefore, the following essential climate variables were selected for the study:

a) GHG emissions
b) wind speed and wind direction, solar irradiance
c) land cover, leaf area index, above-ground biomass and soil carbon.

As the main source of global warming, the GHG concentration in the atmosphere is placed at the core of any efforts in mitigating climate change. GHG emissions represent the key variable in measuring human-caused climate change[6] and in illustrating the progress on reaching climate-related sustainability goals. A comprehensive QI is crucial in evaluating the compliance with international agreements.

Wind speed, wind direction and solar irradiance are not only important variables in monitoring changes in the climate, but also serve as the basis for the development of renewable energies. A transition towards renewable energies is directly related to GHG emissions as electricity and heat generation are still the number one GHG emitters.[7] These variables are the foundation for building well-performing renewable energy installations. They rely on QI for reliable and comparable data.

Another way to reduce carbon in the atmosphere is supporting and conserving the natural sequestration of carbon in the soil and biomass. In particular, data on land cover, leaf area index, above-ground biomass and the soil carbon concentration serves to inform decisions on land use change and environmental protection as well as reforestation initiatives.

Methodology

The study was finalized in June 2017. It is based on extensive desk research as well as six telephone interviews. The desk research focused on existing studies by international organizations, including the IPCC and the UNFCCC. The interviews were carried out with representatives of the QI in Latin America in order to retrieve information about existing initiatives, developments, challenges and opportunities in the focus region. Additionally, an interview with an expert on soil carbon, land cover, leaf-area index and above-ground biomass was conducted to gain deeper insights into this relatively new topic in the context of QI.

Structure

The study first introduces the topic of climate change by describing its causes, and the challenges it poses and then illustrates responses and mitigation efforts by the international community.

In section 4, the study further elaborates on climate change in the region of focus, Latin America and the Caribbean. The specific risks and consequences for the region are listed together with the corresponding fields of mitigation strategies.

Then, after introducing the concept of QI and its different components, the selected climate variables are analysed with respect to the specific layers of QI – that is to say, metrology, standardization, conformity assessment and accreditation – and related initiatives and potential in Latin America and the Caribbean.

Finally, the study aims to provide recommendations on how to further develop the QI regarding climate change monitoring and mitigation in the focus region. The recommendations are based on the gaps identified through the analysis and priorities for sustainable development as defined by the international community.

5 BMZ 2015

6 The Economist 2013

7 IPCC 2014a

3. Climate change – a global challenge

This section introduces the issue of climate change and gives a short overview of international agreements and tools for climate change mitigation. The aim of the section is to provide a background for the analysis of necessary QI services for climate change mitigation, which is presented in section 5.

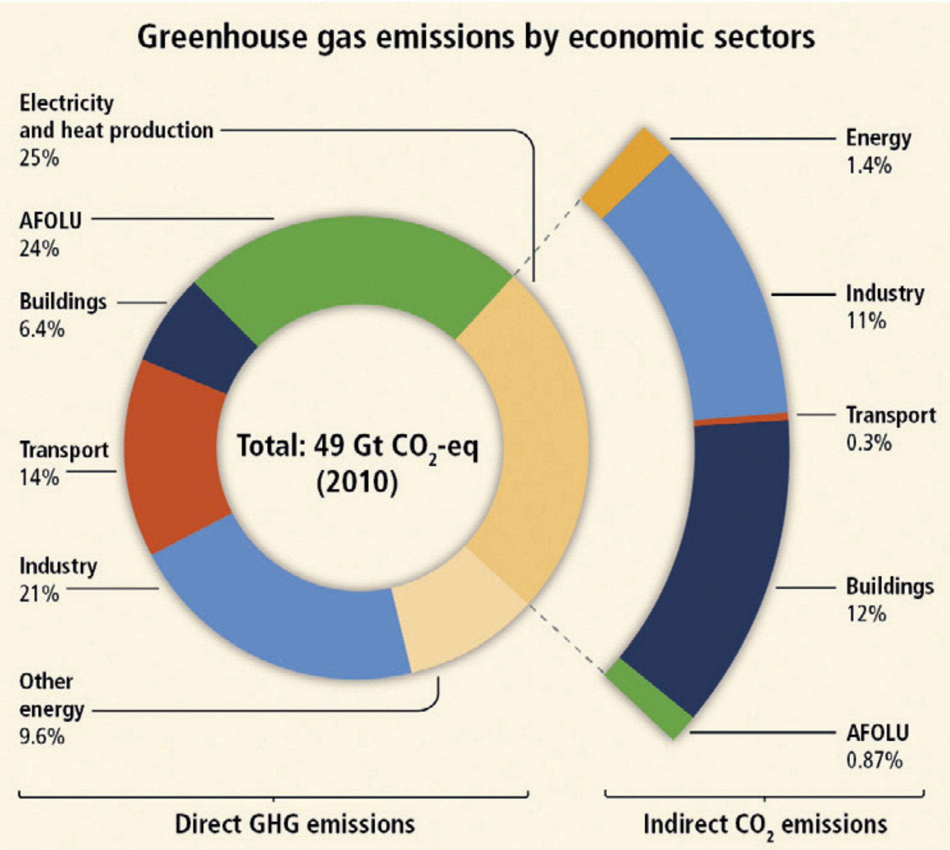
3.1 Climate change – an introduction

Climate change, as defined in the UNFCCC, is "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to national climate variability observed over comparable time periods."[8]

Today, there is strong scientific consensus that the climate is changing globally as an effect of human activities that cause GHG emissions. The most prominent GHG is carbon dioxide (CO2) that is emitted when fossil fuels are burned, for example. Other gases that contribute to global warming are, for example, methane (CH4) and nitrous oxide (N2O).[9]

The economic sectors with the highest GHG emissions globally are industry with considerable direct and indirect GHG emissions, agriculture, forestry and other land use (AFOLU), buildings and transport (figure 1).

Figure 1 GHG emissions in % of total anthropogenic GHG emissions by economic sectors in 2010[10]



8 UN 1992, p.7

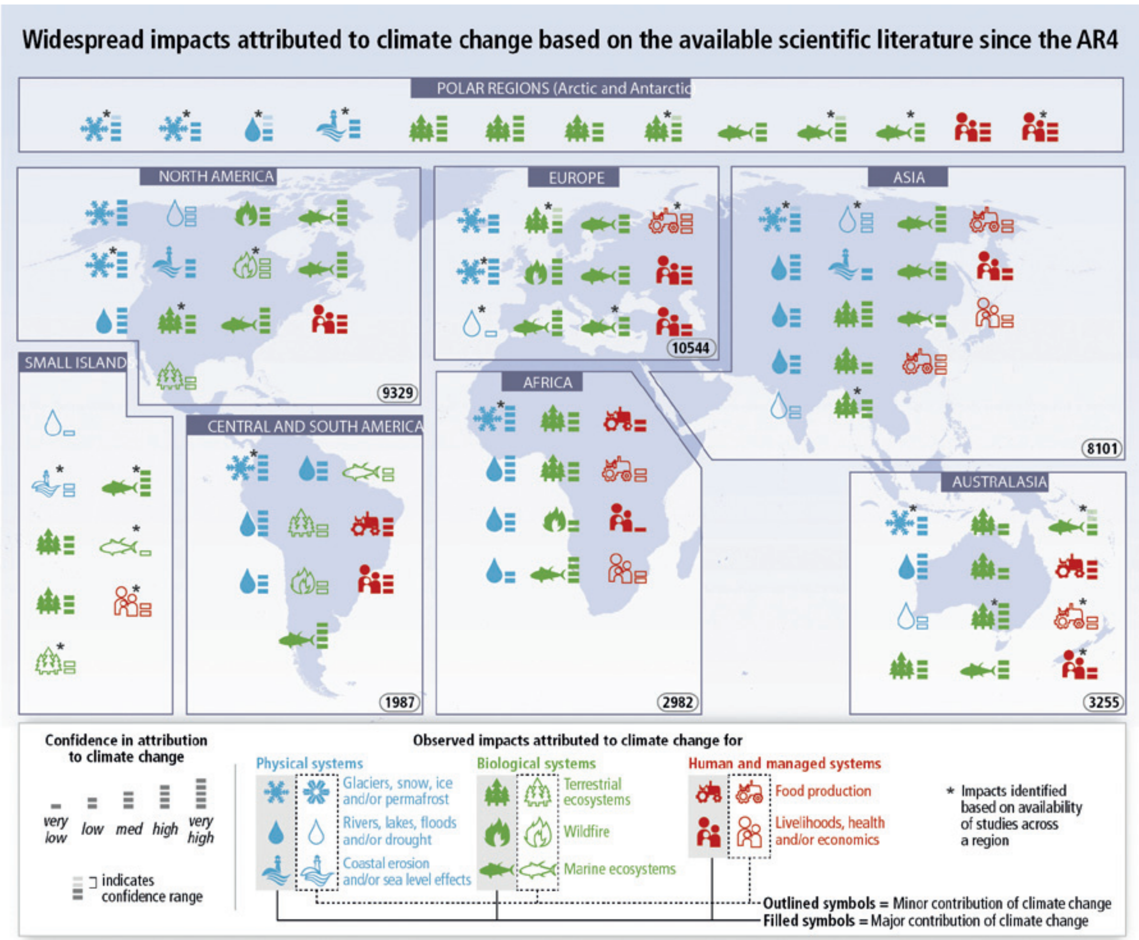
9 WMO 2013, p.1

10 IPCC 2014a, p.47

The effects of climate change are rising temperatures, changes in precipitation, more extreme weather events, melting of snow and ice and permafrost warming. This impacts hydrological systems and water resources. Other effects include changes in animal behaviour and crops, in response to altering temperatures and extreme weather conditions.[11]

Even though the publications are still limited for many regions, systems and processes, the IPCC's Fifth Assessment Report presents an overview of the widespread impacts attributed to climate change around the world. In figure 2, the symbols indicate categories of attributed impacts on physical, biological, human and managed systems, the relative contribution of climate change to the observed impact and confidence in attribution.

Figure 2 Widespread impacts attributed to climate change[12]
Based on scientific literature available from 2001 to 2010 included in the Scopus bibliographic database. The number of publications included is indicated in the figure per region.



11 IPCC 2014a

12 IPCC 2014a, p.7

3.2 The international response to climate change

Limiting climate change requires substantial and sustained reductions in GHG emissions. In order to achieve this, in the frame of meetings of the United Nations (UN), international agreements and declarations have been made addressing this topic. Furthermore, a number of tools have been established to support the countries in achieving the targets agreed upon and in monitoring their progress.

International agreements addressing climate change

The UNFCCC was drafted for the UN Conference on Environment and Development in Rio de Janeiro, Brazil, in 1992 and entered into force in 1994.[13] The convention has the objective of stabilizing GHG concentrations in the atmosphere "at a level that would prevent dangerous anthropogenic interference with the climate system."[14]

Over the years, additional agreements have been reached, with governments pledging to take action. The most important are the Kyoto Protocol to the UNFCCC that entered into force in 2005, setting binding emission reduction targets for industrialized countries,[15] and the Paris Agreement that entered into force on 4 November 2016. The Paris Agreement has the objective to strengthen the global response to climate change in order to prevent temperatures from rising more than 2 °C above pre-industrial levels. A focus has also been put on preparing countries to adapt to the impacts of climate change.[16]

Moreover, climate change is an important topic on the more general agenda for sustainable development. It is addressed in the Sustainable Development Goals that were adopted in 2015 by the 193 countries of the UN General Assembly in the frame of the 2030 Development Agenda *Transforming our world: the 2030 Agenda for Sustainable Development*.[17] The Sustainable Development Goals succeed the Millennium Development Goals, which were agreed upon by the UN member countries in 2000 and set goals for 2015.[18]

Previous declarations on the environment and sustainable development by the UN included climate change and related topics: the Agenda 21, the Rio Declaration on Environment and Development and the Statement of Principles for the Sustainable Management of Forests, which were adopted jointly with the UNFCCC at the UN Conference on Environment and Development held in 1992 in Rio de Janeiro.[19]

Related approaches supporting climate change mitigation

In the frame of the Kyoto Protocol, an international emissions trading system (ETS) was established to help countries meet their targets, and a monitoring, reporting and verification (MRV) tool was developed for monitoring the achievements. The ETS is based on assigned emission amounts for each country and allows countries to trade emission units. This means that countries emitting less GHGs than they are permitted to, can sell their excess capacities to countries that are exceeding their assigned amounts. Additionally, countries can earn removal units through land use projects, such as reforestation, emission reduction units through joint implementation projects, and certified emission reductions through so-called clean development mechanism (CDM) projects carried out in developing countries. The three additional units are equivalent to one ton of CO2 each and can be traded to achieve reduction targets.[20]

An ETS allows a price to be put on GHG emissions and is used as a policy tool for climate change mitigation not only at UN level, but also in regional, national or local contexts. In order to ensure the functioning of the ETS, a common approach and credible information are essential. Through the definition of adequate monitoring, reporting, verification

13 UNFCCC 2014c

14 UN 1992, p.4

15 UNFCCC 2014b

16 UNFCCC 2016

17 UN 2015

18 UN General Assembly 2014

19 UN 1997

20 UNFCCC 2014a

and quality control processes, which are applied by all the participants, comparability, transparency and accuracy can be ensured.[21] Quality infrastructure can play an important role here, as will be explained more in detail in section 5.

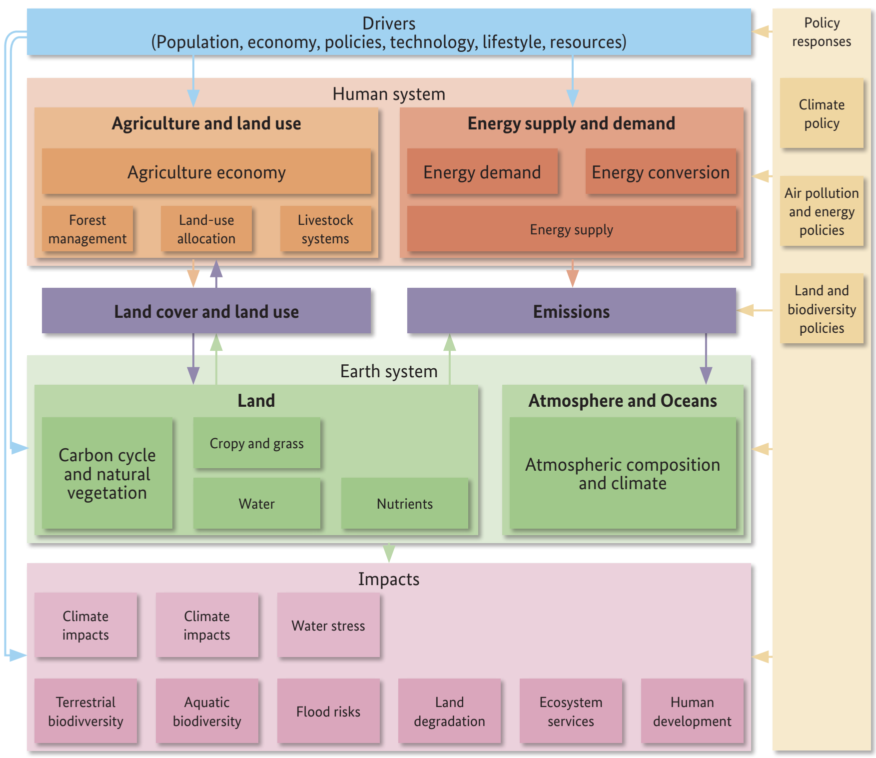
Finally, all transactions should be recorded and participants should report their emission values on a regular basis. In the case of the international ETS for combating climate change at UN level, countries are required to communicate annual emission inventories and national reports on the implementation of mitigation and adaptation efforts.[22]

Another important initiative is the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD) that was launched in 2008.[23] It supports nationally-led REDD+ processes to develop measures for forest conservation, sustainable forest management and the enhancement of forest carbon stocks that allow countries to reduce CO2 emissions resulting from deforestation. REDD+ creates a financial incentive for forest conservation.[24]

Emission reductions cannot only be achieved through direct climate policy, related taxes and initiatives. Also, decisions and policies regarding energy, including energy production, consumption and efficiency, air pollution and land use can have a key impact on climate change mitigation and contribute to the achievement of emission reduction targets as a co-benefit. The interlinkages are shown schematically in figure 3 that gives an overview of aspects to be considered for the assessment of the global environment.

Figure 3 Integrated model to assess the global environment[25]
For more information and an interactive version of the model, please visit PBL's website.

IMAGE 3.0 framework



Source: PBL 2014

21 ICAP 2017
22 UNFCCC 2014b
23 UN REDD Programme 2016b
24 UN REDD Programme 2016a
25 PBL 2014

4. Climate change and the Latin American / Caribbean region

This section summarizes the impact and importance of climate change in the region and presents a selection of initiatives for climate change mitigation that are already being implemented.

4.1 Climate-change-related challenges in the region

Latin America and the Caribbean are home to the highest biodiversity in the world. The climate in the region varies substantially ranging from tropical rainforests to Andean glaciers. The region has historically contributed a very small share of global GHG emissions. As many landscapes are transformed to accommodate the growing industrial and agricultural sector, including cattle production, this contribution is increasing.[26] In spite of the comparably low contribution to emissions, the region is very sensitive to the consequences of climate change.[27] The region is at particular risk for climate change impacts due to its demographic distribution, a high dependence on natural resources and well-functioning agriculture, as well as the great diversity of vulnerable ecosystems. Rising temperatures, changes in precipitation patterns and the occurrence of extreme weather events have been experienced across the region.

Rising temperatures and sea levels

Rising temperatures are both melting the ice on the polar caps and on glaciers while warming the oceans that are then expanding in volume, ultimately causing sea levels to rise substantially.[28] While the actual land loss due to sea-level rise only affects small fractions of the national territories, these areas are frequently the most populous and economically important regions with cities, tourist resorts, and other activities and infrastructure.[29] With the majority of the population living within 100 to 200 km of the coastline, Latin America and the Caribbean will be strongly affected by any rise in sea levels and its consequences.[30] Depending on the extent of the rise in sea levels, a vast amount of the population could be facing increasing threats to their livelihoods due to floods, strong storms and, ultimately, land loss.[31]

Apart from being a threat to human settlements, rising temperatures and sea levels also represent a threat to various coastal ecosystems such as coral reefs, wetlands and mangrove forests and the services they provide.[32] These ecosystems have already been weakened and cannot mitigate the consequences of climate change induced events such as flooding, landslides or soil erosion in times of drought as they used to. The conservation of coastal ecosystems could play a vital role in providing protection from rising sea levels and storms.[33]

Precipitation patterns and extreme weather events

As mentioned before, climate change also affects precipitation patterns and increases the occurrence of extreme weather events across the region. Due to the diversity in ecosystems and different regional climate zones, the changes in precipitation patterns are observed to differ across Latin America. Ultimately, climate change is expected to cause a decrease in precipitation in the Caribbean region, the north east of Brazil, central and southern Chile. On the contrary, precipitation is expected to increase in south-eastern Latin America. [34] The exact extent of these changes in precipitation is unclear and varies regionally. Scientists' projections do however indicate that the extent of these changes will

26 FAO 2017

27 CEPAL 2015

28 NASA 2017

29 IPCC 1997

30 Simpson et al. 2012

31 National Geographic 2017

32 Plag et al. 2015

33 Martin & Watson 2016

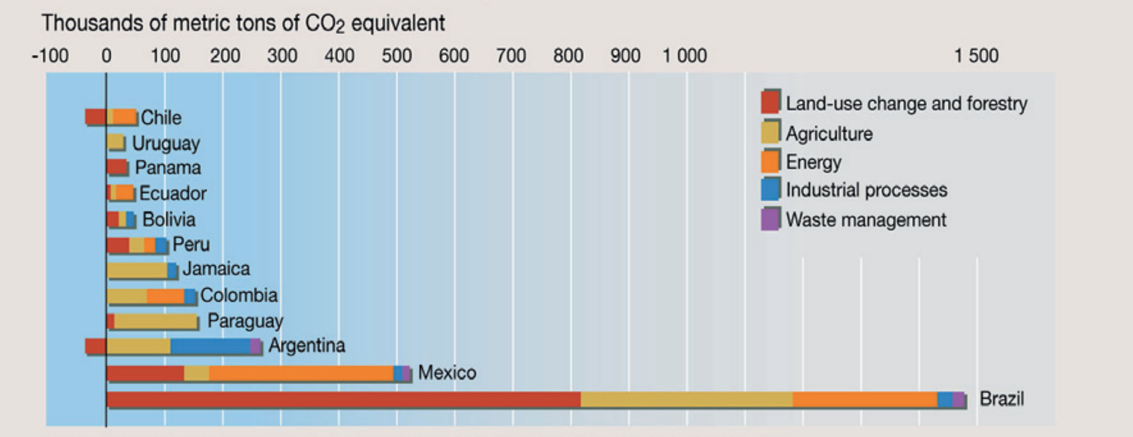
34 CEPAL, 2015

be manifested in increased or decreased rates between 7 % and 25 %, hence causing substantial changes in local ecosystems and affecting biodiversity. Moreover, climate change does not only cause a change in precipitation levels but also in the intensity and occurrence of precipitation.[35] The strong episodes of the El Niño and La Niña phenomena experienced in recent years, suggest a relationship to climate change directly affecting precipitation and temperatures in the Latin America-Caribbean region.[36] Similarly, warmer seas have intensified the strength of tropical storms that hit Central America and the Caribbean.[37]

4.2 Mitigation of climate change

Limiting climate change and reducing the damage requires substantial reductions in GHG emissions across the globe and the maintenance of healthy ecosystems that provide important carbon storage.

Figure 4 Latin America GHG emitters by sector, ECLAC 2009



Source: ECLAC, *Climate Change and Developement in Latin America and the Caribbean. Overview*, 2009.

On a global level, Latin America and the Caribbean contribute only a small portion of GHG emissions and especially on a per capita level, these are comparably low.[38] In this region, the eradication of valuable ecosystems through depletion and destruction constitutes a major source of GHG emissions. In Brazil, for example, more than half of the national GHG emissions can be attributed to deforestation (see figure 4). Most importantly, deforestation and land degradation attributed to agriculture contribute to the acceleration of climate change. The carbon stored in forests is emitted into the atmosphere and simultaneously the capacity to extract carbon dioxide from the atmosphere is reduced.[39] The Latin American forests play a crucial role in this as they represent 22 % of global forest cover.[40] With tropical rainforests being the ecosystem with one of the highest carbon sequestration potentials, the Amazon rainforest contributes significantly to mitigating the effects of carbon emissions.[41] Sustainable forest management is thus very important for climate change mitigation in the region.

Limiting GHG emissions also requires a gradual switch from fossil fuel combustion towards renewable energies. In light of the substantial economic development and population growth experienced in many parts of this region, enabling sustainable growth fuelled by renewable energy sources represents a fundamental challenge to maintaining and

35 IPCC, 2014b
36 IPCC, 2001
37 IPCC, 2007
38 CEPAL, 2015
39 Locatelli et al., 2011
40 FAO 2015
41 IPCC, 2014b

decreasing the comparably low carbon footprint of the region. Besides hydropower, which is already an important energy source in Latin America today, solar and wind energy could also play an increasingly important role in the future. Their relevance is reflected in the investments in renewable energies in Latin America and the Caribbean, peaking at USD 17 billion in 2015 before falling to USD 9 billion in 2016[42].

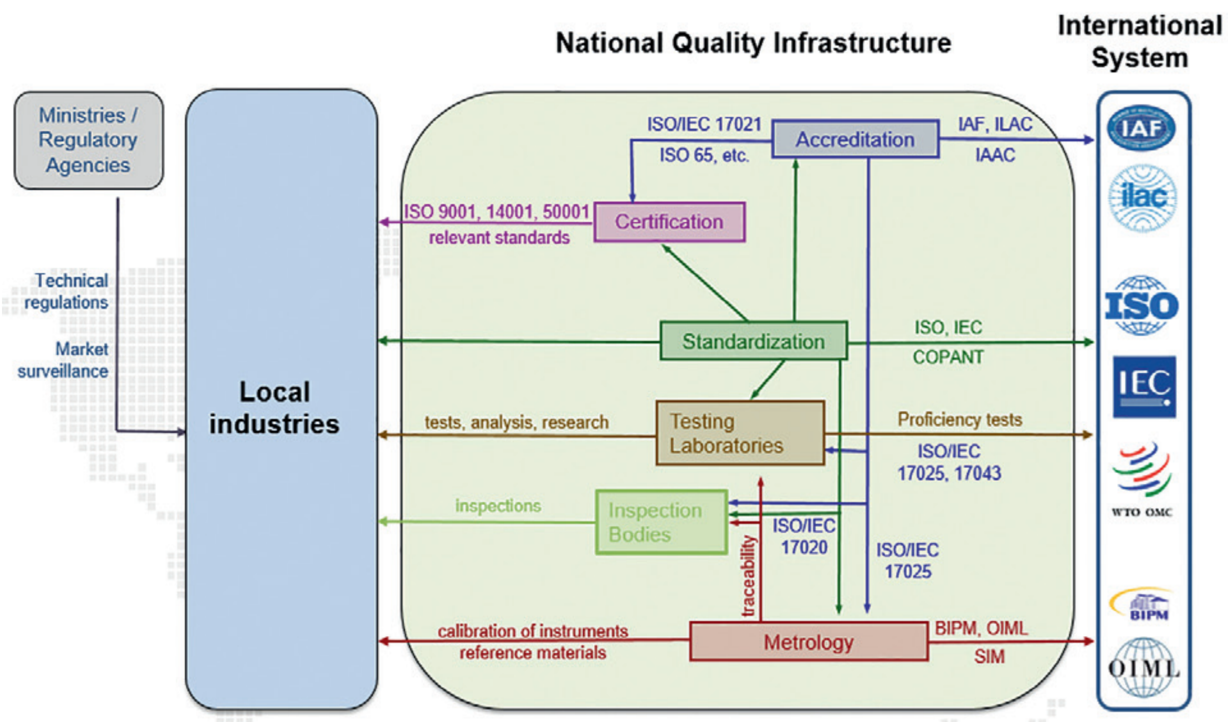
5. The contribution of quality infrastructure to climate change mitigation

This section gives an overview of the QI and describes the relevance of its different components in the context of climate change. Focusing on the selected climate variables, examples of existing services and interesting initiatives in Latin America and the Caribbean are presented.

5.1 Quality infrastructure – an introduction

What is quality infrastructure?
The national QI is a framework of organizations providing services to ensure quality. As illustrated in figure 5, it is comprised of metrology, standardization, accreditation and conformity assessment – including testing, inspection and certification. It is an interrelated system, in which no component can be developed without developing the others as they complement each other. Key entities of the system are a National Metrology Institute, a National Standards Body, a National Accreditation Body as well as conformity assessment bodies.

Figure 5 National quality infrastructure[43]



The national QI should not be developed in an isolated way, but linked to the international system by establishing relations with the respective international and regional organizations, e.g. the International Organization for Stand-

42 IRENA and CPI, 2018

43 Adapted from Telfser et al. 2016

ardization (ISO), the International Electrotechnical Commission (IEC) and the Pan American Standards Commission (COPANT) for standardization, or the International Bureau of Weights and Measures (BIPM) and SIM in the area of metrology. Only in this way it is possible to ensure international traceability[44], comparability and recognition of the local services and to benefit fully from the national QI. Furthermore, the national policy framework and related public institutions are to be seen as a part of the QI since they establish the framework for the different services.

In the following subsections, the components of the national QI, their relevance in the context of climate change, and interesting initiatives in Latin America and the Caribbean are described more in detail.

5.2 Metrology

What is metrology?
Metrology is the science of accurate and reliable measurements. A National Metrology Institute provides traceability for secondary laboratories through calibration services and reference materials. Traceability means that an unbroken chain of comparison measurements is available starting with the instrument used to the primary measurement standards and reference materials that define or materialize a measurement unit on the national or international level. In order to ensure that national measurement units are the same worldwide, metrology institutes participate in international intercomparison measurements. Traceability to an internationally recognized measurement unit makes it possible, for example, to determine how accurate testing results are and how much uncertainty remains, thus allowing results to be compared nationally and internationally. In addition, legal metrology carried out by a government body verifies the accuracy of magnitudes in the country to protect consumers and ensure fair conditions to foster economic development.[45]

The contribution of metrology to climate change mitigation
In the climate change context, accurate measurements are essential. Credible evidence and reliable monitoring of climate change can only be achieved with reliable data. Furthermore, reliable data is an important basis for mitigation efforts. Metrology can ensure the needed confidence in data and thus help provide a sound basis for the management of variables as well as for decision-making on the individual, organizational and political levels.[46]
In order to ensure the comparability of data related to climate change internationally and over time, it needs to be traceable to an internationally agreed reference, ideally the International System of Units (SI). The SI defines internationally agreed upon base units and measurement rules. It is the basis of globally uniform measurements.[47] The complex issue of climate change introduces new variables and metrology needs.[48]

a) GHG emissions

Measurement services for GHG emissions are already well established in developed countries, but rarely in developing and emerging countries, where they are necessarily based on metrological references. The developing and emerging countries and a large part of the IPCC methodologies and models have the challenge of being validated or based on traceable metrological references. In order to determine the amount of GHG emissions generated by a specific activity, GHG concentration and GHG flow need to be quantified.[49] The way this can be done depends on the emission source. GHG emissions can come from point sources (e.g. a stack), or from an area (e.g. a landfill).[50]

44 See 5.2 Metrology
45 Sanetra et al. 2007, p.61-63, 81
46 Interviews 1 & 2
47 Sanetra et al. 2007, p.59
48 Interview 1
49 Johnson et al. 2015, p.4
50 Rausch et al. 2015, p.2

For stacks, for instance, testing devices like continuous emission monitoring systems (CEMS) can be used to monitor emissions. The accuracy of the monitoring can be compromised, if the flow is not uniform or because of uncertainties in the testing of the source dimension, for example.[51] Furthermore, the testing and measurement equipment needs to be calibrated regularly, to verify that the results remain accurate. Relevant metrological services include the provision of measurement standards, reference materials, calibration services and the contribution to the improvement and standardization of testing methodologies.

Area sources, on the other hand, are more difficult to quantify due to their expansion. The uncertainty of emission data gathered from area sources is thus higher than that of point sources. Here, methods still need to be standardized and data needs to be made available to enable comparison and give guidance on the plausibility of the results.[52]

The quantification of GHG emissions is crucial for monitoring and managing climate change.[53] Accurate results are important to ensure compliance with legal limit values, especially in the context of increasingly strict and exigent regulations regarding GHG emissions for various industries and activities. They also play a key role in the frame of international agreements, where all parties need to be able to give information about their GHG emission values correctly, so that the achievement of targets can be evaluated and comparisons between countries can be made.

However, in many cases GHG emission values are not determined by testing. It is common to calculate emissions based on emission factors.[54] Emission factors depend on the processes and inputs used for a certain activity. GHG emission calculation tools often include default emission factors, attributing an approximate value of emissions to a specific activity. However, custom values could produce more accurate results as processes and the composition of organic materials involved may vary between areas or over time[55]. Both, default as well as custom emission factors are based on testing results. However, according to existing literature, comparisons between GHG emission values calculated with emission factors and determined on-site with continuous emission monitoring systems show considerable differences. For power plants, for instance, continuous emission monitoring systems are thought to have a higher potential to increase the accuracy of emission values.[56] By increasing the accuracy of testing results, metrology can thus also help reduce uncertainty, improving the accuracy of emission factors for specific processes and inputs and increasing the comparability of reported GHG emission values.

b) Solar irradiance, wind speed and wind direction

Solar irradiance, wind speed and wind direction have traditionally been part of the realm of meteorology. Therefore, the responsibilities of metrology and meteorology are not always clearly separated.[57] Increased collaboration between metrology and meteorology, the consolidation of calibration services and the completion of chains of traceability are important to increase the accuracy of these variables.[58] They are necessary not only for climate change monitoring, but also to facilitate the development of renewable energies. Amongst other things, an important area to be further developed is the calibration of pyranometers[59], used for example in weather stations.

c) Land cover, leaf area index, above-ground biomass and soil carbon

The experience and maturity of processes of the global metrology community regarding different climate variables vary considerably[60] and for many of the variables, processes, methodologies and technologies to ensure the accuracy needed

51 Johnson et al. 2015, p.4-5

52 Rausch et al. 2015, p.2

53 Rausch et al. 2015, p.1, Interviews 1 & 2

54 An emission factor is a representative value that indicates the approximate quantity of emissions associated with a specific activity. (EPA 2016)

55 The GHG Protocol, for example, recommends using custom values. (Greenhouse Gas Protocol 2017b)

56 Johnson et al. 2015, p.3

57 Interview 1

58 Interview 2

59 A pyranometer is an instrument for measuring solar radiation.

60 Interview 1

still have to be developed.[61] The monitoring of land use change and the quantification of variables to give information on related decisions is a relatively new field for metrology. The selected variables are not directly measurable and have been considered only marginally from the metrological perspective so far.[62] Concrete needs for measurement and metrological services still have to be defined. While land cover, leaf area index and above-ground biomass require mainly visual monitoring,[63] soil carbon concentration can be determined both through calculation formulas based on the properties of different soil types and through direct analysis. Direct analysis could generate more accurate results, which, however, are determined by a number of factors. Soil carbon is not evenly distributed across areas and soil layers and it varies greatly between different types of soils, ecosystems and climatic regions.[64] A standardized measurement approach does not exist to date[65] and measurement results are not comparable internationally.[66]

Initiatives and potential in Latin America and the Caribbean
As is the case globally, and also in Latin America and the Caribbean, the development of metrological services for the climate variables selected for this study varies widely.

Currently, the highest priority is given to the development of capabilities for the measurement of GHG emissions. Mexico and Brazil are developing secondary capabilities in this area.[67] For a list of calibration and measurement capabilities (CMCs) presented by the national metrology institutes of Mexico and Brazil, as well as additional information on comparison measurements and available services, please refer to annex 2.

Several other countries including Argentina, Uruguay, Peru, Colombia and Costa Rica are developing their capabilities for GHG measurements.[68] However, in many countries, these measurements are still unreliable and traceability cannot be provided.[69] Especially in the Caribbean, more collaboration between countries is needed, as not all countries have the resources to provide all services or to have their own reference materials.[70]

Training and technology transfer initiatives are being carried out to develop metrological services for GHG emissions. Two PTB activity lines in the frame of the *Regional Fund Quality Infrastructure for Biodiversity and Climate Protection* focus on strengthening national metrology institutes in the region in the areas of GHG and exhaust emissions, respectively.[71]

The development of capabilities for the magnitudes related to wind and solar irradiance is still not very advanced. Primary capabilities have not been developed so far.[72] At present, only very few national metrology institutes in Latin America offer calibration services for pyranometers, which are used to measure solar irradiance, and – according to the available information – there are no accredited secondary laboratories. Due to that, the reliability of solar irradiance data in Latin America, which is an important basis for the development of solar energy, may be questioned in some cases. Some metrology institutes are developing relevant services. In Peru, for example, calibration services for photometers are being developed. Photometers can be used to measure light intensity or brightness, luminous flux, light distribution or colour, usually by comparing the light emitted by two different sources.[73] The development of such services is determined by the needs of local industries and national plans for the expansion of renewable energies.[74]

61 BIPM – WMO p.8-9

62 Interviews 1 & 5

63 Interviews 1 & 5

64 Lefèvre 2017, pp.32-45 & Interview 5

65 Lefèvre 2017, p.38 & Interview 5

66 Interview 5

67 Interview 1

68 Interview 1

69 Interview 2

70 Interview 1

71 Interview 1

72 Interview 1

73 Dictionary.com 2017

74 Interview 2

In the first place, the responsibilities of metrology and meteorology for the quality assurance of climate data need to be clarified. In many countries, solar irradiance, wind speed and wind direction are mostly monitored by the meteorology institutes, but cooperation with metrology laboratories for the calibration of the equipment is very limited. A new activity is currently being discussed in the frame of SIM and the *Regional Fund Quality Infrastructure for Biodiversity and Climate Protection*. The focus lies on bringing together metrology and meteorology to work on selected magnitudes and clarify the respective roles and needs.[75]

For the measurement of land cover, leaf area index, above-ground biomass and soil carbon, Latin American metrology institutes are not known to have carried out any activities to date. Monitoring and quantification activities are being carried out without quality control, as is the case globally.[76]

5.3 Standards related to climate change

What is standardization?
Standards are voluntary specifications for products, services and systems that ensure quality and safety. They also play an important role in increasing efficiency, especially but not only in the context of international trade.

ISO is an independent, non-governmental international organization with a membership of 162 national standards bodies and provides a frame for experts to develop consensus-based international standards. More than 21000 international standards and related documents for a variety of sectors have been published so far.[77]

Apart from ISO, other organizations are involved in the development and publication of standards. This second type of standards is often focused on a specific context, like the GHG Protocol or the Carbon Disclosure Project (CDP) in the field of GHG emission reporting for example, or the Forest Stewardship Council (FSC) working on the topic of sustainable forestry (see below).

In many cases, there are links between the two types of standards. ISO standards are not developed for a specific programme or initiative, but are often referred to in national policies, programmes and guidelines of international initiatives. At the same time, lessons learned from other international initiatives and standards in the relevant field are often used as input for the development of ISO standards.

National standardization bodies are responsible for standardization in their country. They identify standardization needs, coordinate national mirror committees (MC) for the adoption of international standards, their adaptation to local conditions or the development of national standards, if necessary. Furthermore, the national standardization bodies publish the standards, organize events, raise awareness and inform the public about available standards. Only if they are widely known and applied, can standards have the intended effects.

The contribution of standardization to climate change mitigation
Climate change is a global problem that needs to be tackled by different actors worldwide. Standards are of major importance in such a diverse context as they facilitate the harmonization of activities by providing an internationally agreed upon framework to guide climate protection efforts. The contribution of standards is manifold; for example, they can:
- be used as a reference for regulatory measures by governments, e.g. by specifying environmental criteria
- support quality and risk management and increase the efficiency of management systems
- ease the exchange and communication of data through the definition of comparable criteria, e.g. climate data, reporting and labels
- enable comparisons through standardized procedures, e.g. for testing
- ensure quality criteria in audits and inspections.

75 Interview 1

76 Interview 1

77 ISO 2017a

The identification of standardization needs in the context of climate change with the relevant stakeholders, the elaboration of new international standards and the adoption of international standards on a national level are therefore crucial. ISO has developed over 570 international standards with relevance to climate change mitigation and adaptation so far.[78] Where international standards are still missing, national standardization bodies have the important task to develop national standards in response to specific local needs.

With respect to the selected climate variables, standardization efforts in the areas of GHG emissions and renewable energies are more advanced, while fewer standards related to land use change have been developed.

a) GHG emissions

Standards related to GHG emissions have been developed by various organizations. Within ISO, Subcommittee 7 of Technical Committee (TC) 207 focuses on GHG emissions and has published a number of standards addressing the quantification and reporting of GHG emissions for organizations, projects and products, quality assurance, validation and verification processes. New focus areas related to GHG emissions, in which international standards are under development, are a framework for climate change adaptation, and climate finance[79] (see annex 3 for a full list of standards published and under development in this subcommittee).

In spite of the advancements in standardization for GHG emissions, the Climate Change Coordination Committee of the ISO Technical Management Board identified a number of opportunities for improvement in their final deliverable in 2015. Some of the recommended priorities for ISO were:
- assuring internal coherence for GHG emission quantification and reporting throughout distinct ISO standards
- evaluating the need for possible GHG Management System Standards and Sectoral GHG Accounting Standards
- defining / clarifying links of ISO standards with other international standards as well as with international disclosure programmes.[80]

The clarification of links between standards from different organizations is particularly important for GHG emission quantification and reporting. Here, a number of other initiatives also provide guides and standards that are widely used to facilitate and harmonize GHG emission accounting and communication internationally. Some examples are given below:
- The GHG Protocol is a GHG accounting tool that was developed by the World Resource Institute and the World Business Council on Sustainable Development in 2001. Due to the extensive existing experiences with the GHG Protocol, it was used as a basis for the development of the ISO14064 standard on GHG emission quantification and reporting.[81]
- The CDP provides a platform for standardized data collection that enables companies, cities, states and regions to monitor and manage their environmental impacts, including GHG emissions. The data gathered in this way is then analysed to provide information about the risks and opportunities.[82]
- The Verified Carbon Standard (VCS) aims to develop and manage standards that help countries, the private sector and civil society in achieving their sustainable development and climate action goals. It integrates the principles of the relevant ISO standards (ISO 14064 and ISO 14065) in order to quantify benefits and encourage investment in responsible, high-performing projects and programmes.[83]

b) Solar irradiance, wind speed and wind direction

With respect to the variables solar irradiance, wind speed and wind directions, existing standards focus mainly on quality assurance for specific technologies, including related products, processes, systems and services (e.g. ISO 9846

78 ISO 2015c

79 ISO 2017c, Interview 3

80 ISO 2015a, p.7

81 Greenhouse Gas Protocol 2017a

82 CDP 2017a

83 VCS 2017, ISO 2015c, p.5

and 9847 for the calibration of pyranometers, ISO 16400 for the design of wind turbine gear boxes, or IEC 62446 for testing requirements for PV systems).[84] Especially for international standards related to technologies, it is often necessary to adapt the requirements to local conditions. In the case of solar photovoltaic modules, for example, specific climatic conditions in a country determine which aspects of the international standard are relevant. A hail test, for instance, might not be necessary in tropical countries, while the effects of elevated humidity levels or salt mist may be more important to consider. National standardization bodies thus have the important role of actively participating in the development of international standards to include their perspective in the standards and, once they are published, of adapting international standards to the local conditions if needed.

c) Land cover, leaf area index, above-ground biomass and soil carbon

In the area of land use change, the availability of ISO standards is still limited. An environmental management standard is currently being developed to guide the establishment of good practices for combating land degradation and desertification (ISO 14055). This standard is intended, amongst other things, to support policy makers worldwide in fighting the effects of land degradation. It is expected to be published in 2017[85] and will be complemented by a Technical Report with implementation examples as guidance.[86] Moreover, ISO is developing a standard on the chain of custody of wood and wood-based products (ISO/DIS 38200).[87]

Other initiatives are already further advanced. The FSC, for example, was the first organization to create a system of sustainable forestry standards with the goal to sustain and improve ecological, economic and social factors in forestry organizations through certification. The organization also encourages the adaptation of its international standards to regional legal, social and geographic conditions.[88]

Another example is the Climate, Community and Biodiversity Standards Program of the VCS. It provides guidance to evaluate the benefits of land use projects in addressing climate change, supporting local communities and smallholders and conserving biodiversity.[89]

Initiatives and potential in Latin America and the Caribbean

In Latin America and the Caribbean, international standards related to environmental management are adopted in most countries after translation. The Spanish Translation Task Force (STTF) heads the working group for the translation of the ISO standards published in English. This allows the duplication of translation work to be avoided, but represents a further delay before the international standard can be adopted or adapted by the national standardization bodies.[90] Some national standardization bodies, for example the Institute of Technical Standards of Costa Rica (INTECO), may therefore decide to translate international standards individually as soon as they are published, not making use of the task force.[91]

Currently, particularly Costa Rica, Colombia and Argentina are participating actively in the TC of ISO on Environmental Management. In order to foster the participation of more countries in international standards development, COPANT organizes workshops to inform its members about the activities of the TC and promote participation. Additional workshops are organized in collaboration with PTB, to prepare the member organizations for the participation in one of the biannual plenary sessions organized by ISO and to follow up on the event.

In many cases, a lack of resources creates an obstacle to national standardization bodies participating in ISO meetings for standards development. ISO encourages participation through virtual channels. However, it was suggested in the

84 Interview 3

85 Naden 2016

86 Interview 3

87 ISO 2017b

88 FSC 2017a&b

89 CCBA 2017

90 Interview 3

91 Interview 7

interviews that direct contact between the participants, for example in a regional event carried out in parallel, might increase their confidence and willingness to participate.

As for the other standard setting initiatives mentioned above, all of the standards are applied in Latin America. To mention just a few, the CDP is applied in regions in Brazil, Ecuador, Guadeloupe and Mexico.[92] Bolivia is the first country worldwide to have developed a national standard for the Bolivian Natural Forest based on the FSC Forest Stewardship Standard.[93] Moreover, the standards of the VCS Climate, Community and Biodiversity Standards Program are employed in various projects across Latin America. The majority of these projects are part of REDD+.[94]

5.4 Conformity assessment

What is conformity assessment?
Conformity assessment services include testing, inspection and certification. They are carried out to confirm whether a product, material, service, system or person complies with a standard (see 5.3), regulatory requirement or specification. Conformity assessment bodies can obtain accreditation from an internationally recognized accreditation body to show that the services are carried out correctly and competently (see 5.5). Test results are only reliable if calibrated equipment and certified reference material are used (see 5.2).

The contribution of conformity assessment to climate change mitigation
Conformity assessment bodies play an important role in the context of climate change. They are necessary to evaluate the conformity of products, materials, services, systems or people with the requirements of the above-mentioned standards, climate policies, or other criteria. In doing so, they provide confidence that related activities are carried out correctly and that communicated data is credible.

Testing services in the area of climate change include, for example, testing of GHG emissions and exhaust fumes for specific production processes or products. Testing laboratories can also carry out soil carbon content analysis.[95] For the variables land cover, leaf area index and above-ground biomass, local testing services are less relevant. For land cover, for instance, high-quality visual information regarding these variables is generated through satellite pictures by international organizations.[96] As a basis for the development of solar and wind energy, in particular, meteorological laboratories and weather stations monitor solar irradiance, wind speed and wind direction to provide data on possible locations for renewable energy installations. Additionally, for renewable energy technologies, a variety of testing services can be used to ensure conformity with a specific product standard. Moreover, complete installations can be tested for correct functioning. In the case of solar power plants, amongst other things, the testing of solar irradiance at the plant location can be used to determine the performance of the plant.[97]

For renewable energy plants, **inspection** services are relevant. Inspections can be conducted to assess whether the installation has been carried out correctly. Moreover, inspections can play a role in sustainable forestry management, depending on local legislation. In the area of GHG emissions, inspection services are less relevant. Certification bodies or specialized verification organizations usually carry out the verification of GHG emission accounting.

There are several **certification** schemes with relevance in the climate change context. In the area of sustainable forestry, for instance, wood and wood products can be certified in accordance with the FSC standards mentioned above. Another well-known certification scheme for wood and wood products is the Chain of Custody certificate of the Pro-

92 CDP 2017b

93 FSC 2004

94 CCB 2017

95 In this area, important quality challenges exist. Due to the lack of standardized methods and traceability, data obtained is not comparable internationally. (Interview 5)

96 Interview 5

97 Telfser et al. 2016

gramme for the Endorsement of Forest Certification Schemes (PEFC). In the frame of VCS, projects can achieve certification if they comply with the respective VCS standard. For renewable energies, product certification according to the relevant ISO or IEC standard is very common. With respect to GHG emissions, emission accounting can be verified according to ISO 14064-3, in which an independent conformity assessment body evaluates whether the requirements of the standard ISO 14064-1 or 14064-2 regarding GHG inventories and emission reductions have been applied. Regular verification is often a requirement in emission trading schemes.

Initiatives and potential in Latin America and the Caribbean

As is the case for metrological capacities, also the development of testing services is strongly dependent on country-specific needs and demand. Often, this demand is generated by new legislation. In many Latin American countries, political interest in climate change monitoring and mitigation is growing and policies and laws increasingly address related topics. For solar and wind energy, for instance, national targets, policies and programmes are crucial for the development of the sector and of the necessary conformity assessment services in response to increasing demand. Moreover, technical regulations and the inclusion of quality criteria in tendering documents play an important role. An example is the inclusion of testing requirements in the tendering documents for public renewable energy programmes. Some countries in the region have systematically included such criteria with reference to international standards, which significantly increases the demand for testing services and improves quality assurance in the sector.

Certification for a variety of schemes is available in Latin America and the Caribbean. For example, in the area of sustainable forest management, PEFC certification is available in Mexico as well as in other countries. Certification bodies need to be accredited (see 5.5) to be able to certify a wood products' compliance with PEFC requirements for responsible forest management. The certification generates various benefits for companies: it opens new markets, improves risk management and sustainability performance, and ensures compliance with legal requirements throughout the value chain. Two thirds of certified forest area worldwide are PEFC certified. Additionally, in Mexico, sustainable forest management certification according to the Californian Climate Action Reserve program is available. In the area of GHG emissions, Mexico is one of the most advanced Latin American countries and has eight certification bodies accredited in accordance with ISO 14065 for the verification and validation of GHG assertions.[98]

Initiatives in testing, inspection and certification regarding the climate variables land cover, leaf area index, above-ground biomass and soil carbon were not reported. The definition of standardized methods at a global level needs to be advanced before relevant national services can be developed. Moreover, especially with respect to the visual monitoring of land cover, it needs to be evaluated whether such services are necessary nationally, or if it is preferable to have them carried out by specialized international organizations.[99]

5.5 Accreditation

What is accreditation?

Accreditation refers to the formal recognition that a conformity assessment body is competent of carrying out a specific task. In the frame of an accreditation, the body is assessed with respect to the implemented quality management system as well as to the professional competence in the specific area for which the accreditation is being carried out. In order to achieve international recognition of the accreditation and increase the reliability and confidence in the QI services provided in a country, the National Accreditation Body should participate in peer evaluations regionally and internationally and establish mutual recognition and multilateral arrangements.[100]

98 Interview 6

99 Interview 5

100 Sanetra et al. 2007, pp. 96-102

The contribution of accreditation to climate change mitigation
Accreditation is important to ensure that conformity assessment is carried out competently on a national level, giving confidence in the results of laboratory tests, inspections and certificates. This is also relevant in the context of climate change.

In the area of **testing**, accreditation according to ISO/IEC 17025 confirms the overall competence of testing and calibration laboratories.[101] This is relevant, for instance, for the analysis of GHG emissions, to ensure the reliability and international comparability of the data obtained.

For **inspection** services, accreditation can be carried out in accordance with ISO/IEC 17020, in which the operation of inspection bodies is reviewed and evaluated in general.[102] Accreditation can provide confidence that the inspection of renewable energy power plants is carried out by competent inspection bodies according to international standards, for example. This can foster the interest of international investors in renewable energies.

The accreditation of **certification** bodies for products, processes and services can be carried out following the requirements of ISO/IEC 17065.[103] For audits and the certification of management systems, accreditation according to ISO/IEC 17021 is possible.[104] Specific accreditation for the validation and verification of GHG emission assertions can be achieved according to ISO 14065. The standard sets out specific requirements for the accreditation or recognition of validation and verification services. Further accreditation services exist for certification schemes in climate-change-relevant areas, such as sustainable forestry. The availability of such services depends on the needs and demand in each country as well as on the ability of the national accreditation body to develop specific services.[105]

Apart from accreditation services related to these standards, it is also important that the services of the national accreditation body are recognized in other countries. The international and regional organizations including the International Accreditation Forum (IAF), the International Laboratory Accreditation Cooperation (ILAC) and the Inter-American Accreditation Cooperation (IAAC) provide a platform for exchanging and supporting the establishment of mutual recognition agreements between countries. This is of particular relevance in the context of international initiatives and agreements, as it allows the establishment of trust in the conformity assessment services by the participating countries. The mutual recognition of accreditation according to ISO 14065, for instance, allows the streamlining of verification and validation processes, as well as processes for quantifying GHG emissions, and an increase in the transparency and consistency of GHG emission reporting.[106]

In the European Union, for example, 26 national accreditation bodies conducted peer evaluations for accreditation according to ISO 14065 in the frame of a European Accreditation Multilateral Agreement as required by Article 64 of Commission Regulation (EU) No 600/2012. These aforementioned bodies accept the accreditation certificates for validation and verification bodies issued by the other signatory accreditation bodies.[107]

Also within the Pacific Accreditation Cooperation, the following countries participated in peer evaluations for a Multilateral Recognition Arrangement for GHG validation and verification: Japan, USA, Mexico, Taiwan (China), Hong Kong (China) and Sri Lanka.[108] In Latin America, Multilateral Recognition Arrangements for the accreditation of specific climate-relevant conformity assessment services are not known at present.

101 ISO 2005

102 ISO 2012a

103 ISO 2012b

104 ISO 2015b

105 Interview 4

106 Kubo 2016, p.8

107 European Accreditation 2014

108 Pacific Accreditation Cooperation 2017

Accreditation is not always carried out by a national accreditation body. For some climate-relevant initiatives, parallel structures to the ones in accordance with the ISO standards were created. For the implementation of the UNFCCC, accreditation is required for CDM measures, for instance. The Executive Board of the CDM is responsible for the accreditation of validation and verification bodies and can provide "formal recognition of an entity's institutional capacity and competence to carry out the CDM validation and/or verification and certification functions in accordance with the CDM rules and requirements."[109]

Initiatives and potential in Latin America and the Caribbean

In South America, all countries have a National Accreditation Body. In the Caribbean, on the other hand, some small countries do not have sufficient demand and resources to establish their own body. Nevertheless, they have a designated person who is responsible for accreditation-related topics and are represented in the IAAC by the CARICOM regional organization for standards and quality. Agreements between national accreditation bodies are common and accreditation services are often carried out in collaboration with an accreditation body from another country.[110]

Fifteen national accreditation bodies of Latin America and the Caribbean are signatories of mutual agreements (MLA) within the IAAC. All of them provide internationally recognized accreditation services for testing laboratories and 12 of the bodies also provide such services for calibration laboratories. Additionally, in Brazil and Mexico, accreditation for proficiency testing providers and reference material producers is available.[111]

Regarding accreditation for certification bodies, Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Peru and Uruguay have signed the MLA for quality management system and product certification bodies. Also, Paraguay is a signatory of the latter. Moreover, most of those bodies offer internationally recognized accreditation for environmental management system certification.[112]

In addition to the general accreditation services for certification bodies, accreditation for sustainable forestry certificates is a topic of interest in Latin America. This is closely related to the third category of climate variables including land cover, leaf area index, above-ground biomass and soil carbon. In Mexico, for example, an accreditation scheme for certification bodies for the PEFC Chain of Custody certificate for wood and wood-based products was launched in March 2017. The certification bodies are accredited according to the requirements of ISO/IEC 17065 and the specific technical requirements of PEFC[113]. In Colombia and Ecuador, specific programmes are being developed in collaboration with the local regulators.[114]

Internationally recognized accreditation for inspection bodies is available in Argentina, Brazil, Chile, Costa Rica, Cuba, Ecuador, Guatemala, Mexico, Nicaragua, Paraguay and Peru. Directly related to climate change, the Mexican Accreditation Body signed an MLA within the IAAC on accreditation for the validation and verification of GHG emission assertions in March 2017. Also Colombia has expressed interest in this topic and more Latin American countries might follow in the coming years.[115]

109 UNFCCC 2017, p.7

110 Interview 4

111 Interview 4

112 Interview 4

113 Interviews 4 & 6

114 Interview 4

115 Interview 4

6. Recommendations

Based on the findings of the study, the following recommendations can be made:

General recommendations
Climate change needs to be put on the agenda of QI institutions and at the same time **awareness about the importance of QI for climate protection** should be raised. In order to achieve this, dialogue and information events between stakeholders of the relevant sectors and representatives of the QI on concrete needs in the context of climate change should be supported. Current and future needs in the context of climate change should also be discussed in regional QI forums, such as the IAAC, SIM and COPANT. In this way, best practices can be identified and possibilities to support the member countries in the development of new services relevant in the context of climate change can be defined.

Stronger **collaboration between countries in Latin America**, and especially in the Caribbean, for the development of the relevant QI services is recommended. A regional strategy for the development of metrology services relevant in the context of climate change could be defined to focus the efforts in the region and allow the coordination of working areas between different countries. In this way, high-quality services in different areas can be ensured by specialized metrology institutes.

Quality criteria should be included in technical regulations, guidance documents and tendering documents, for example for emission monitoring or renewable energy power plants. In this way, the accuracy of climate change monitoring and the efficiency of mitigation efforts can be improved.

The **collaboration between the metrology and meteorology** community with regard to variables related to climate change should be fostered. An improved exchange between the two stakeholder groups, for example in regional meetings, could help to clarify responsibilities and lead to agreement upon methods and processes to be followed in order to improve the accuracy and comparability of climate data.

Recommendations for PTB
The study identified a need for the development of QI services in the context of climate change. It is therefore recommended that PTB maintains its **support on a regional level** and increasingly supports triangular cooperation amongst countries in Latin America and the Caribbean to foster the cooperation between leading countries and organizations interested in developing new QI services.

Moreover, PTB should **evaluate the experiences** made in the activities carried out in the frame of the *Regional Fund Quality Infrastructure for Biodiversity and Climate Protection in Latin America and the Caribbean* and further develop and expand such activities. Creating incentives for concrete initiatives and fostering the cooperation between QI organizations and stakeholders of the relevant sectors appears to be a successful approach.

Climate change is high on the political agenda globally. Considering national climate policies and the need for an integrated and holistic approach to QI development, the potential for **bilateral projects with specific focus** on QI development for climate protection should be evaluated. Systematic investigations on specific needs of the national industries for QI services related to GHG emission and renewable energies should be conducted and used as a basis for the development of the national QI.

Additionally, PTB should support the **inclusion of climate-related topics** in regional QI forums and promote the involvement of Latin American and Caribbean stakeholders in international discussions. This is especially important in topics related to land use that are very relevant in the region.

PTB could also **facilitate the dialogue between QI institutions and stakeholders of the relevant sectors** to foster the development of innovative services and products relevant for climate change (e.g. new certification services, labels, climate-friendly products that require services of the QI). Amongst other things, the CALIDENA methodology[116] could be used in this context.

Thematically, the following prioritization for supporting the development of relevant QI services is suggested:

- GHG emissions
- solar irradiance, wind speed and direction
- variables related to land use change as well as characterizing soil carbon

PTB can play an important role in **raising awareness and providing information** about the importance of QI for climate protection. Publications like the current study, dialogues and information events are key in spreading information about QI in the context of climate change.

116 CALIDENA is a participatory methodology developed and implemented by PTB to stimulate quality in value chains. It aims to systematically and sustainably support the improvement of the QI in developing and emerging economies. For more information, please refer to the handbook: https://www.ptb.de/cms/fileadmin/internet/fachabteilungen/abteilung_q/q.5_technische_zusammenarbeit/q5_publikationen/204_Guide_Calidena/PTB_Q5_Guide5_Calidena_EN.pdf"

Annex 1 Essential climate variables of the global climate observing system

In the frame of the Global Climate Observing System (GCOS), 50 essential climate variables were defined in 2010. They include atmospheric, oceanic and terrestrial information needed for historic and current observations.

Table 1 GCOS essential climate variables[117]

Domain	GCOS essential climate variables
Atmospheric (over land, sea and ice)	**Surface** (*at standardized but globally varying heights in close proximity to the surface*): air temperature, wind speed and direction, water vapour, pressure, precipitation, surface radiation budget
	Upper-air (*up to the stratopause*): temperature, wind speed and direction, water vapour, cloud properties, earth radiation budget (including solar irradiance)
	Composition: carbon dioxide, methane and other long-lived GHGs (including nitrous oxide – N2O, chlorofluorocarbons – CFCs, hydrochlorofluorocarbons – HCFCs, hydrofluorocarbons – HFCs, Sulphur hexafluoride – SF6, perfluorocarbons – PFCs), ozone and aerosol supported by their precursors (in particular nitrogen dioxide – NO2, sulphur dioxide – SO2, formaldehyde (HCHO) and carbon monoxide (CO)
Oceanic	**Surface** (*within the upper 15 m*): sea-surface temperature, sea-surface salinity, sea level, sea state, sea ice, surface current, ocean colour, carbon dioxide partial pressure, ocean acidity, phytoplankton
	Sub-surface: temperature, salinity, current, nutrients, carbon dioxide partial pressure, ocean acidity, oxygen, tracers
Terrestrial	River discharge, water use, groundwater, lakes, snow cover, glaciers and ice caps, ice sheets, permafrost, albedo, land cover (including vegetation type), fraction of absorbed photosynthetically active radiation (FAPAR), leaf area index (LAI), above-ground biomass, soil carbon, fire disturbance, soil moisture

117 Global Climate Observing System 2017

Annex 2 CMCs, comparison measurements and available services related to GHG emissions of the national metrology institutes of Mexico and Brazil

The national metrology institute of Mexico (CENAM) has presented Calibration and Measurement Capabilities (CMCs) for the following gases for the energy and environmental sectors:

- stack gas multi-component mixture – quantifying nitrogen monoxide, sulphur dioxide, carbon monoxide, carbon dioxide and propane
- recognized core or basic capabilities in gas analysis based on binary gas mixtures, basically in nitrogen – quantifying the components carbon monoxide, nitrogen monoxide, propane, carbon dioxide, methane, oxygen and sulphur dioxide
- synthetic natural gas – quantifying n-butane, i-butane, propane, ethane, carbon dioxide, nitrogen, methane, n-pentane, i-pentane, and n-hexane.

CENAM offers a programme for value assignment to gas mixtures from producers and analytical services for all of the above. Additionally, it offers calibration services of gas mixtures and sometimes of instruments for nitrogen and synthetic natural gas balances.[118] CENAM has participated in preparative and analytical comparisons in gas analysis to maintain its core capabilities, including pilot, supplementary and key comparisons. It has also taken part in comparison measurements for carbon dioxide in air and in the first pilot preparative comparison of CCQM-GAWG of carbon monoxide in nitrogen; multi-component gas mixtures; nitrogen monoxide, carbon monoxide, and oxygen in nitrogen; the analysis of ten binary mixtures; analytical comparisons of standards of sulphur dioxide and of propane, both in nitrogen; n-hexane in methane, and natural gas type I, II and III. It is the coordinating institution in a comparison measurement for synthetic natural gas measurement composition.[119] CENAM has basic capabilities for stack and mobile emission measurements, and air quality premixtures covering critical air pollutants in Mexico, with the exception of particulate matter and ozone, the latter being done by the Mexican DI National Institute of Ecology and Climate Change (INECC). CENAM is also expanding its capabilities to cover GHGs of carbon dioxide and methane at emission levels and carbon dioxide at emission levels, also including biogas. To create more awareness amongst users, CENAM also offers proficiency tests on demand, several of them explicitly recognized in the framework of the MRA-CIPM.

In Brazil, INMETRO has presented CMCs for the following gases:

- carbon dioxide in synthetic air or nitrogen – range 100 ppm to 1000 ppm (the GHG range to CO2 is 380 ppm to 780 ppm)
- methane in synthetic air or nitrogen – the minimum range is 30 ppm but the GHG minimum range is 1 ppm
- sulphur oxide in nitrogen – range 50 ppm to 5000 ppm
- nitrogen monoxide in nitrogen – range 30 ppm to 70 ppm.

INMETRO offers calibration services for carbon dioxide, methane, nitrogen monoxide, carbon monoxide, propane and sulphur dioxide measurement equipment.[120] It has participated in comparison measurements for carbon dioxide in air; carbon monoxide, carbon dioxide, nitrogen monoxide, propane and water vapour in nitrogen; natural gas type I, II and III; comparison on natural gas; comparison of primary standard gas mixtures: gravimetric production of CH4 in synthetic air; automotive emission gases; analytical comparison of standards of sulphur oxide in nitrogen.[121]

118 BIPM 2015b

119 BIPM 2017b

120 BIPM 2015a

121 BIPM 2017a

Annex 3 ISO Standards for GHG management and related activities[122]

Table 2: ISO Standards related to GHG emissions

Standard Number	Standard Name	Status
ISO 14064-1	Greenhouse gases – Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals	Under development
ISO 14064-2	Greenhouse gases – Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements	Under development
ISO 14064-3	Greenhouse gases – Part 3: Specification with guidance for the validation and verification of greenhouse gas assertions	Under development
ISO 14065	Greenhouse gases – Requirements for greenhouse gas validation and verification bodies for use in accreditation or other forms of recognition	Under development
ISO 14066:2011	Greenhouse gases – Competence requirements for greenhouse gas validation teams and verification teams	Published
ISO/TS 14067	Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification and communication	Under development
ISO/TR 14069:2013	Greenhouse gases – Quantification and reporting of greenhouse gas emissions for organizations – Guidance for the application of ISO 14064-1	Published
ISO/DIS 14080	Greenhouse gases management and related activities – Framework for adaptation to climate change	Under development
ISO/WD 14090	Greenhouse gases – Framework for adaptation to climate change	Under development
ISO/AWI 14091	Climate change adaptation – A guidance to Vulnerability Assessment	Under development
ISO/AWI TS 14092	GHG management & related activities: requirement & guidance of adaptation planning for organizations including local governments and communities	Under development
ISO/NP 14097	Framework and principles for assessing and reporting investments and financing activities related to climate change	Under development
ISO/NP 19694-1	Stationary source emissions – Determination of greenhouse gas (GHG) emissions in energy-intensive industries – Part 1: General aspects	Under development

Note: International Standards and other deliverables published by ISO or jointly with IEC must be systematically reviewed, at the latest after a certain period of time (see table 3) has passed. A review can be initiated by the secretariat of the committee responsible or by the ISO secretariat, typically once the maximum time has elapsed. Alternatively, it can be requested by one or more national standards body, or the CEO. As a result of the review, the deliverable can be confirmed, revised or amended, converted to another form of deliverable, or withdrawn.[123]

122 ISO 2017c

123 ISO/IEC 2017

Table 3: Timing of systematic reviews

Deliverable	Max. elapsed time before systematic review	Max. number of times deliverable may be confirmed	Max. life
International Standard	5 years	Not limited	Not limited
Technical Specification	3 years	Once is recommended	6 years recommended
Publicly Available Specification	3 years	Once	6 years (if not converted after this period, the deliverable is proposed for withdrawal)
Technical Report	Not specified	Not specified	Not limited

Up-to-date information about the status of a standard can be found on the ISO website.

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List of interviewees

Name	Position and Institution*	Role in Regional Fund*
Bernd Bussian	Independent Consultant, Germany	–
Claudia Santo	Metrology Director, LATU, Uruguay	Representative of SIM in PSC
José Dajes	Metrology Director, INACAL, Peru	Representative of SIM in PSC
María Aurora Agulló	Senior Coordinator, IRAM, Argentina	Representative of COPANT in PSC
Martha Mejía	Technical Director, EMA, Mexico	Participating institution
Verónica García Malo	Independent Consultant, FRASO Alliance, Mexico	Intermittent Expert
Victor Gandy	Executive Secretary, IAAC, USA	Representative of IAAC in PSC

* at time of interview

List of abbreviations

AFOLU	Agriculture, Forestry and Other Land Use
BIPM	International Bureau of Weights and Measures
BMZ	German Ministry for Economic Cooperation and Development
BSD	Business Sustainability Development
CARICOM	Caribbean Community
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CDP	Carbon Disclosure Project
CEMS	Continuous Emissions Monitoring Systems
CENAM	Centro Nacional de Metrología – National Metrology Institute of Mexico
CMCs	Calibration and Measurement Capabilities
COPANT	Pan American Standards Commission
EMA	Entidad Mexicana de Acreditación – National Accreditation Body of Mexico
ETS	Emissions Trading System
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FSC	Forest Stewardship Council
GHG	Greenhouse Gas
GCOS	Global Climate Observing System
IAAC	Inter American Accreditation Cooperation
IAF	International Accreditation Forum
IEC	International Electrotechnical Commission
INMETRO	Instituto Nacional de Metrologia, Qualidade e Tecnologia – National Metrology Insitute of Brazil
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
LAI	Leaf Area Index
MLA	Mutual Agreements
MRV	Monitoring, Reporting and Verification
PEFC	Programme for the Endorsement of Forest Certification Schemes
PSC	Project Steering Comittee
PTB	Physikalisch-Technische Bundesanstalt
QI	Quality Infrastructure
REDD	Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
SI	International System of Units
SIM	Inter-american Metrology System
TC	Technical Committee
UN	United Nations
UNFCC	United Nations Framework Convention on Climate Change
VCS	Verified Carbon Standard
WMO	World Meteorological Organization
WTO	World Trade Organization

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Responsible
Dr. Marion Stoldt
+49 531 592-9300
marion.stoldt@ptb.de
www.ptb.de/9.3/en

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Niels Ferdinand, Katharina Telfser

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Physikalisch-Technische Bundesanstalt

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Contact

Physikalisch-Technische Bundesanstalt
International Cooperation
Dr. Marion Stoldt
Tel +49 531 592-9300
Fax +49 531 592-8225
marion.stoldt@ptb.de

www.ptb.de/9.3/en