Enablers of ambitious climate action

Challenges and opportunities to combine climate change and sustainable development

Gabriela Ileana Iacobuţă

2021

Propositions

1. All development (cooperation) finance should consider climate-related effects to ensure long- term effectiveness. (this thesis)
2. Coherently addressing SDG 13 on climate action supports achieving all other SDGs. (this thesis)
3. Dangerous climate change (i.e. global average temperature increase above 1.5°C) has a much more disruptive effect worldwide than COVID-19.
4. In the future, artificial intelligence will be necessary to conduct literature reviews and identify research gaps.
5. In raising climate-change awareness, the bold action of young climate activists is more effective than decades of international negotiations.
6. Adequately communicating with oneself is the key to success.

Propositions belonging to PhD thesis titled:

“Enablers of ambitious climate action: Challenges and opportunities to combine climate change and sustainable development”

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Thesis

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Contents

Beaches are being reduced by sea-level rise.
Photo taken in Whitehaven Beach, Australia, 2012.

Communities are affected by salt intrusion into ground water.
Photo taken in Zanzibar, Tanzania, 2010.

1

Introduction

"The Parties to this Agreement, . . . Recognizing the need for an effective and progressive response to the urgent threat of climate change on the basis of the best available scientific knowledge"

Paris Agreement, Preamble.

1.1 Background

The United Nations Framework Convention on Climate Change (UNFCCC) was established at the Earth Summit in Rio de Janeiro in 1992, when countries jointly acknowledged the dangers of climate change as a "common concern of humankind" (UNFCCC, 1992, Preamble, p. 2). This Convention called for global action and cooperation to tackle climate change (Box 1.1.), while noting countries' "common but differentiated responsibilities and respective capabilities [CBDR-RC] and their social and economic condition" (ibid.). Ever since, countries have been negotiating and setting up mechanisms to increase climate-action ambitions to the levels required to avoid dangerous anthropogenic interference with the climate system. However, almost three decades later, countries are still struggling to reach this ambition under the urgency of a rapidly changing climate.

Box 1.1. The objective (Article 2) of the UN Framework Convention on Climate Change (UNFCCC) *(I emphasized parts of the text.)*

The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would **prevent dangerous anthropogenic interference with the climate system**. Such a level should be achieved within a time frame sufficient to **allow ecosystems to adapt naturally to climate change**, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

International climate negotiations have adapted to the reality of an ever-changing world that led to a growing contribution of developing countries (especially China, Brazil and India) to global greenhouse-gas (GHG) emissions. While only developed countries were expected to take action and report on their emissions reductions in the past, developing countries should now also report on their Nationally Appropriate Mitigation Actions in the context of sustainable development. This mechanism was set out at the 17th and 18th Conference of Parties in Bali (2007) and Doha (2008) and coined in the 2009 Copenhagen Accord. With the adoption of the Paris Agreement in 2015, all countries have agreed to put forward Nationally Determined Contributions (NDCs), which they would update every five years to ensure a maximum global temperature increase of well below 2°C, and to strive to further limit this to below 1.5°C, as a legally-binding goal. However, current NDCs are far from reaching this goal and a postponement of adequate action in the past implies a need for much stronger emissions reductions over the coming decades (Höhne et al., 2020). Nevertheless, while emissions should be halved by 2030 to keep the world on track to the 2°C target, a slight emission increase is expected instead, based on current NDCs. What is more, a full implementation of the NDCs is rather unlikely as many countries are currently not on track to meet their targets (ibid.; Roelfsema et al., 2020). Hence, countries should now urgently raise their ambitions on climate action to reach the Paris Target.

In the same year that the Paris Agreement was reached, the UN's General Assembly adopted the 2030 Agenda on Sustainable Development. This international agenda comprises of seventeen Sustainable Development Goals (SDGs) covering environmental, social and economic targets that apply to all countries equally and that should be met by 2030. While the 2030 Agenda has developed under a different international process than the Paris Agreement, the two international agendas are strongly intertwined. First, SDG 13 of Agenda 2030 is dedicated to climate change. Second, the impacts of climate change would lead to significant losses and pose a threat to all areas of sustainable development (Hoegh-Guldberg et al., 2018). Third, addressing climate change through mitigation or adaptation requires deep socio-economic transformations that could positively or negatively affect the ability to meet other SDGs (Roy et al., 2018). Fourth, economic growth, industrialization and infrastructure development, access to services by a larger share of the global population, and growing consumption can be contingent with GHG emissions reductions and have been the main barriers to bold climate action (UNEP, 2016). In this sense, how countries will choose to pursue the SDGs would have strong implications for how GHG emissions levels will evolve in the years to come.

In recognition of the interlinkages between various international agendas and between the SDGs themselves, the 2030 Agenda calls for enhanced policy coherence (SDG Target 17.14) that minimizes goal conflicts and maximizes synergies. Yet, countries are still learning how to achieve such coherence for climate and sustainable development objectives.

1.2 Climate action enablers and related research gaps

Although less than ten years are left until 2030, both the 2030 Agenda and the Paris Agreement goals are currently far from being met (UN, 2019b). Despite important recent announcements and actions, such as the adoption of the European Green Deal, the re-joining of the United States to the Paris Agreement, the Group of 7 commitment to jointly achieve net zero emissions by 2050, and China's promise to aim for carbon-neutrality by 2060, measures to reduce GHG emissions remain insufficient (Climate Action Tracker, 2021; Roelfsema et al., 2020). With the climate crises looming over the world and a rapidly rising global temperature, pushing for bold climate action is now more imperative than ever. To that end, identifying and leveraging enablers of ambition are essential to clear obstacles and support the required deep transformation. In the following, I present climate action enablers that have been explored in the past, and discuss key knowledge gaps that still remain.

First, international climate negotiations with a clear objective to stimulate national climate action globally are considered a key enabler. Multiple agreements have been reached, whereby countries pledged GHG-emissions reductions commitments and established international support mechanism for finance, technology, capacity building and carbon offsetting. However, real emissions reductions can only be achieved through domestic action and research has shown that adoption of national climate laws have had a quantifiable positive impact (e.g. Dubash, 2020). While multiple databases have collected information on national climate-relevant policies and measures[1], more information on the link between the adoption of national measures and key moments in the international climate negotiations can be investigated as potential enablers over time.

Second, historically, the CBDR-RC principle required developed countries to reduce GHG emissions in a top-down approach, but how this principle and other country contexts played out in a bottom-up target-setting approach under the Paris Agreement still needs investigation (Winkler, 2020). Nowadays, developed and developing countries alike must put forward climate action pledges (i.e. NDCs) - conditional or

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1 For example, the Climate Policy Database, NewClimate Institute, Wageningen University and Research and PBL, Available at: http://climatepolicydatabase.org/; Climate Change Laws of the World database, Grantham Research Institute on Climate Change and the Environment and Sabin Center for Climate Change Law. Available at: http://www.lse.ac.uk/granthaminstitute/legislation/.; Policies and Measures Database, International Energy Agency, Available at: https://www.iea.org/policies/about.

unconditional upon international support. Nevertheless, the principle of CBDR-RC still plays a role in climate negotiations as the Paris Agreement calls for fairness and equity to be reflected in the ambition of the NDCs. Yet, no guidelines are provided on how fairness and equity should be determined. So far, countries' indication of fairness in their NDCs has been assessed, but without an analysis of actual relative ambition (Winkler et al., 2018). Additionally, the ambition levels of individual country pledges relative to fairness and equity concepts have been analysed (Aldy et al., 2017; Höhne et al., 2017; Pan et al., 2018; Robiou Du Pont et al., 2017; Yann Robiou du Pont, 2017; Zimm & Nakicenovic, 2020), but without assessing which concepts countries gravitate towards when self-determining ambition. Understanding how the CBDR-RC principle plays out in countries' climate ambitions is essential to facilitate the process of 'soft reciprocity' (i.e. role-models inspire other countries to take more ambitious action) and peer pressure (i.e. unambitious countries are pressured by others to step up climate-action ambition) in international climate negotiations (c.f. Falkner, 2016; Weikmans et al., 2020).

Third, international climate assistance is essential to enable strong climate action in developing countries and a better understanding of its influence on countries' NDC pledges could motivate and improve allocation. Many countries have set targets conditional upon international support (Pauw et al., 2020) and securing such support would make these countries more likely to increase their ambition in the future (Pauw & Klein, 2020). Yet, to what extent receiving climate finance in the past, has motivated more ambitious conditional pledges as a result of enhanced capability is still unknown. While the Copenhagen Accord of 2009 requested developed countries to jointly mobilize US$100 billion a year by 2020, the world is still far from reaching this goal (UNFCCC SCF, 2018) and a postponement to 2025 has been recently agreed (at the 25th Conference of Parties in Madrid). Moreover, the debate on what represents climate finance remains open (Romain Weikmans & Roberts, 2019).

Fourth, given the interlinkages between climate and sustainable development action, aligning priorities between climate and development finance could facilitate a more efficient use of resources. Research has shown that NDCs are not only climate plans but also development plans, whereby climate activities directly address most SDGs (Brandi et al., 2017; Janetschek et al., 2020). Countries' priorities and plans have been made transparent through the NDCs. An assessment of alignment between proposed NDC activities and climate-relevant development finance could elucidate whether official development finance has been made more coherent with recipient countries priorities. Countries are not living up to their promises concerning development finance for the implementation of the SDGs and using existing resources effectively is key (UN, 2019b).

Fifth, in addition to addressing some specific SDGs directly, climate mitigation measures also affect many others, both positively and negatively. As indicated earlier, addressing trade-offs and enhancing synergies between climate and sustainable development priorities could boost climate ambition. The interactions between climate action and the social, environmental and economic dimensions of development have been examined for decades (e.g. Beg et al., 2002; Kok et al., 2008; Nordhaus, 1977; Swart et al., 2003; von Stechow et al., 2016). Yet, while some approaches bring more insights into the nature of these interactions (Roy et al., 2018) they are still limited in facilitating the design of policy mixes that would support coherence between climate and the SDGs. In that sense, an improved overview of the context dependence of specific interactions and the types of complementary measures that could enhance policy coherence in each specific context, could be a strong enabler of higher ambitions. Moreover, an assessment of climate activities in the NDCs relative identified positive and negative impacts to the SDGs could elucidate if countries are already prioritizing more beneficial activities.

Finally, addressing the interlinkages between climate and other sustainable development areas in pertinent international strands of negotiations can further support climate action internationally and nationally. While the SDGs are highly comprehensive and ambitious in nature, they only represent ‘soft law’ and their role can be strengthened through relevant strands of international cooperation. Climate action, represented by SDG 13, interacts with a wide range of other social, economic and environmental SDGs. Based on countries pledged climate activities in the NDCs, SDG 15 (life on land) is the second most addressed SDG after SDG 7 (energy) (Adis Dzebo et al., 2019; Janetschek et al., 2020). SDGs 14 and 15 are directly addressed by the UN Convention on Biological Diversity (CBD) while climate action (SDG 13) falls under UNFCCC. Given the strong interaction in implementation, the two Conventions have to be effectively integrated to maximize synergies and address trade-off between their objectives.

Hence, the literature points towards four major potential enablers of ambitious climate action:

1. key moments in international climate negotiations;
2. country contexts and the CBDR-RC principle;
3. international climate assistance; and
4. policy coherence for the joint implementation of climate and the SDGs, whereby I discussed four levels:

a. coherence between national and international action (i.e. adoption of appropriate measures nationally);
b. coherence of finance;
c. socio-economic and environmental coherence; and
d. coherence between international agendas.

While significant progress has been made in better understanding these enablers, important gaps still remain.

1.3 Objective and research questions

My thesis aims to address the aforementioned research gaps and further explore how the four major enablers of ambitious climate action have played out over time and across countries. Moreover, it aims to develop tools that allow countries to compare the ambition of their climate pledges in the context of the CBDR-RC principle; better align climate and sustainable development finance; provide an overview of climate and SDG interactions and opportunities for enhanced policy coherence; and assess gaps and opportunities for a better integration of the international climate and biodiversity agendas. From a policy perspective, my different assessments probably facilitate comparability and an increased climate ambition among countries.

To achieve these objectives, the thesis addresses the following research questions (RQs):

RQ1 What are the observed changes in adopting national climate-change mitigation strategies, legislation, greenhouse-gas (GHG) emissions targets, renewable energy targets and energy-efficiency targets over the period 2007-2017 and how are these changes correlated with key moments in international climate negotiations? (Chapter 2);

RQ2 Are measures of capability and responsibility correlated with the ambition of GHG-emission-reduction targets put forward by countries in their Nationally Determined Contributions? (Chapter 3);

RQ3 Has climate-related finance historically targeted priority areas described in developing countries' Nationally Determined Contributions and has this finance been better correlated after the Paris Agreement? (Chapter 4);

RQ4 What are the effects of climate-change mitigation measures on the Sustainable Development Goals and how can these be addressed to minimize trade-offs and maximize synergies between the Paris Agreement and Agenda 2030? (Chapter 5); and

RQ5 How do the international Conventions on Climate Change (UNFCCC) and on Biological Diversity (CBD) address common drivers of climate change and biodiversity loss and how could these international agendas be further integrated to enhance co-benefits and reduce trade-offs between their measures? (Chapter 6).

1.4 Thesis outline

Each of the three research questions presented above are addressed in a dedicated chapter from Chapter 2 to Chapter 6. Hence, the core chapters in my thesis explore specific enablers of ambitious climate action amongst the four identified enablers, which are further synthesized in Chapter 7 (see Figure 1.1 for a detailed structure of this thesis).

Chapter 2 explored international cooperation as a stimulator for the adoption of national climate legislation, strategies and targets, while Chapter 3 viewed it as a platform to increase ambition of GHG emissions reductions across NDC cycles (Chapter 2). Country contexts are explored in particular through indicators of capability and responsibility, in line with the CBDR-RC principle, but also from the perspective of climate-development positive and negative interactions (Chapters 2 and 5). While I recognize that institutional, knowledge, technological and other means are also important factors, these fell out of the scope of my studies due to time constraints and expertise limitations. Similarly, while international financial assistance can take different forms, I only focus on climate-relevant finance reported by the Development Assistance Committee members to the Organization for Economic Co-operation and Development (OECD) (Chapters 3 and 4). This finance reporting system is still one of the most commonly used for climate finance reporting (Weikmans & Roberts, 2019). Finally, policy coherence as a means to implement both the Paris Agreement and the 2030 Agenda is addressed, whereby I and my collaborators assess coherence between national and international measures (Chapters 2 and 5), coherence of finance sources and priorities (Chapter 4), coherence of policy objectives (Chapter 5) and coherence of international agendas (Chapter 6). As a discussion and synthesis of my studies, Chapter 7 addresses all four major enablers of climate action and the key results of this thesis.

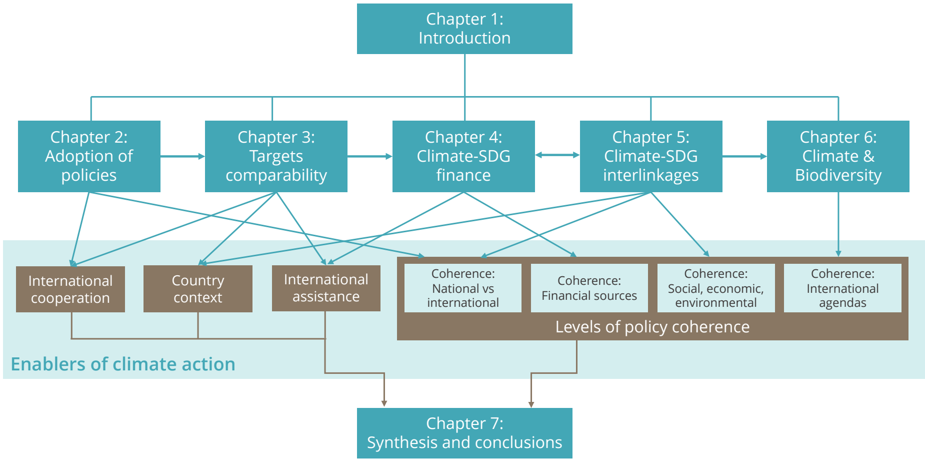

Figure 1.1 Structure of this thesis. Individual chapters explore major enablers of climate action. The enablers are discussed and synthesized in Chapter 7.

To reach my objective and answer all research questions, I and my collaborators conducted global analyses of climate policies, covering both national and international measures. As the main process that is currently guiding the international climate negotiations and stimulating the increase in climate-action ambition, I made the Paris Agreement central to my research. Nevertheless, the influence of other key international climate moments and agreements have also been considered. For instance, the Copenhagen Accord of 2009 was a pivoting moment that set a goal for international climate-finance mobilization and that led developing countries to also report on climate action. Moreover, as sustainable development was shown to be a key enabler or disabler of ambitious climate action, I also discuss Agenda 2030 and its SDGs extensively, in particular in Chapters 4, 5 and 6. In Chapters 4 and 5 we analyse climate and sustainable development interlinkages across all SDGs. In Chapter 6, we thoroughly assess connections between the SDGs on climate change (SDG 13) and on biodiversity loss (SDGs 14 and 15) and discuss the necessary integration between the CBD and UNFCCC decisions.

Chapter 2 examines how the adoption of national climate-change legislation, strategies and targets for GHG-emissions reductions, renewable energy and energy efficiency have changed between 2007 and 2017. This ten-year period covers key moments in international climate negotiations such as the Copenhagen Accord and the Paris Agreement, but also the transition from the first to the second phase of the Kyoto Protocol at the end of 2012. Hence, we assess how these events in international negotiations have influenced the uptake of national policies and analyse differences between developed and developing countries and between geographical regions.

Chapter 3 focuses on how GHG-emissions reductions pledged in the NDCs correlate with several development-specific indicators that represent different country contexts. For that purpose, GHG-emissions reduction pledges were normalized for comparability. To assess correlations with country contexts, indicators that are relevant to capability (i.e. GDP/capita, carbon intensity of the economy, fossil fuel dependence and international climate-relevant finance received), and responsibility (i.e. GHG per capita), were used.

Chapter 4 dives deeper into the effects of international climate-relevant finance. For that purpose, we use the links between NDCs climate activities and the SDGs to determine how countries' climate priorities address key development areas. We further categorize development areas of climate-relevant official development assistance based on the SDGs. Combining the two, this chapter analyses coherence between climate-relevant finance and NDC activities of recipient countries through an SDG lens, pre- and post-Paris.

Chapter 5 addresses sustainable development as both a key enabler and disabler of climate action. First, we identify all negative and positive impacts of climate mitigation measures on individual SDG targets and determine whether these are dependent on specific country contexts or bound to occur in any context. Second, we identify the context types (i.e. time horizon, geographical, governance and natural resources) that would magnify or reduce each specific impact. Using these categories, this chapter identifies potential complementary policies that could be used in each case to reduce adverse impacts and maximize benefits.

Chapter 6 explores the interlinkages between climate and other sustainable development areas in international fora. Here, we focused on how UNFCCC, CBD and the UN Environment Assembly address common drivers of climate change and biodiversity loss. We identify gaps and opportunities for further integration of these international agendas to enhance synergies and to reduce trade-offs between climate and biodiversity action.

Chapter 7 further discusses the four major enablers of climate action and synthesizes the results of the core chapters. Moreover, I put these results into the context of current international negotiations and processes and provide recommendations for policy makers, negotiators and relevant international organizations to enable more ambitious climate action.

My thesis addresses several knowledge gaps that relate to the major enablers of climate action and contribute to existing literature and ongoing national and international processes that address climate change. Moreover, in doing so, my thesis also strongly contributes to other areas of international cooperation and development. Concretely, the 2030 Agenda on Sustainable Development of UN's General Assembly and the UN CBD are analysed through the lens of climate action. Among others, my collaborators and I found that international negotiations positively affected national measures, but the Paris Agreement process of enhancing climate action has not yet proved able to stimulate all countries to adjust their targets (although some did in late 2020). Climate-relevant finance mostly aligns with recipient SDG priorities, but donors' preference for mitigation action is visible. Finally, climate action is strongly interlinked with a wide range of development areas and policy goal coherence is needed nationally and internationally to address potential trade-offs.

Glaciers (feeding rivers) are losing mass and disappearing due to climate change.
Photo taken in Goðafoss, Iceland, 2016.

Higher numbers of annual snow-free days are observed in various regions.
Photo taken in Aguille du Midi, France, 2014.

2

National climate change mitigation legislation, strategy and targets: a global update

Iacobuta, G., Dubash, N. K., Upadhyaya, P., Deribe, M., & Höhne, N. (2018). National climate change mitigation legislation, strategy and targets: a global update. *Climate Policy*, 18(9), 1114-1132.

Abstract

Global climate change governance has changed substantially in the last decade, with a shift in focus from negotiating globally-agreed GHG reduction targets to nationally determined contributions, as enshrined in the Paris Agreement. This paper analyses trends in adoption of national climate legislation and strategies, GHG targets, and renewable and energy efficiency targets in almost all UNFCCC Parties, focusing on the period between 2007 and 2017. The uniqueness and added value of this paper resides in its broad sweep of countries, the more than decade-long coverage, and the use of objective metrics rather than normative judgements. Key results of this paper show that national climate legislation and strategies witnessed a strong increase in the first half of the assessed decade (2007-2017), likely due to the political lead up to the Copenhagen Climate conference in 2009, but have somewhat stagnated in recent years, currently covering 69% of global GHG emissions (almost 50% of countries). In comparison, the coverage of GHG targets increased considerably in the run up to adoption of the 2015 Paris Agreement and 93% of global GHG emissions are currently covered by such targets. Renewable energy targets saw a steady spread, with 79% of the global GHG emissions covered in 2017 compared to 45% in 2007, with a steep increase in developing countries.

2.1 Introduction

Global climate governance has undergone a substantial shift between 2009, when the Copenhagen Climate Conference (the 15th Conference of the Parties - COP 15) to the United Nations Framework Convention on Climate Change (UNFCCC) was held, and 2015, when the Paris Agreement was adopted. From long-standing efforts to negotiate a predominantly top-down governance architecture, the Paris Agreement represents a shift to a hybrid structure that substantially rests on bottom-up national pledges. These pledges, or Nationally Determined Contributions (NDCs), are aimed at limiting the increase in global temperature to well below 2°C above pre-industrial levels and pursue efforts to limit it to 1.5°C. Although the sum of the NDCs currently falls short of this aim (Höhne et al., 2017; Rogelj et al., 2016; UNEP, 2017) the Paris architecture is designed to ratchet up national pledges through a series of top-down nudges, including a global stocktake exercise, to be conducted every five years beginning in 2023 (UNFCCC, 2015). Understanding the full impact of these internationally-declared yet nationally determined pledges will require exploring and tracking how they complement actual national climate actions by means of legislation, strategy, and targets in countries.

This paper updates and expands on an earlier paper that analysed trends in the establishment of climate legislation and/or national strategies in almost all UN member countries between 2007 and 2012 (Dubash et al., 2014). Reflecting the global conversation at the time, the paper was motivated by the proliferation of national policies and actions, a trend that has only increased in the intervening years (Burck et al., 2017; Nachmany et al., 2017). The construction of a new global climate architecture focused on promoting action at national scale reinforces the need to track and analyse national climate legislation, strategy and targets.

This study, building on previous research, provides a comprehensive review of national climate legislation and strategy on climate mitigation for the decade of 2007-2017. The scope of the paper encompasses 194 countries; almost all of the UNFCCC members. Significantly, it focuses on countries' domestic measures, rather than on international statements of intent alone. In addition to the previous paper, this study also examines the prevalence of targets, notably on greenhouse gas (GHG) emissions, renewable energy and electricity, and energy efficiency, including countries' NDCs. By spanning the critical climate negotiation events of COP 15 in Copenhagen in 2009and COP 21 in Paris in 2015, the paper enables an assessment of the effects of international climate negotiations on national legislation, strategy, and target setting. To enable comprehensive comparative metrics, the results are presented with respect to time, number of countries, global emission shares, and global population shares, both globally and across geographical regions. Collectively, the paper provides an important snapshot of climate legislation, strategy and targets every five years and indicates trends in each of these over time.

After a review of the methods applied so far in the literature (Section 2), we describe our method in detail (Section 3) followed by results (Section 4) and conclusions (Section 5).

2.2 Tracking climate action: a review of studies

With the growth in national climate legislation, strategy and targets aimed at climate mitigation – collectively referred to as "climate action" in this paper – the literature on national climate policy-making has expanded over recent years. For example, an important line of research seeks to discuss mechanisms through which climate actions work through national systems, by exploring and comparing climate governance using national case studies (Bang et al., 2015; Harrison & Sundstrom, 2010; Held et al., 2013). Another strand of literature, to which this paper seeks to add, focuses less on underlying causal explanations within a country and seeks to track and explain development in climate action over time across multiple jurisdictions (CAT, 2016; Dubash et al., 2014; GRI, 2017). This strand of literature suggests that international policy diffusion plays a significant role in global climate policy by spreading legislation in countries that do not have formal obligation to any treaty agreement, thus complementing formal treaty obligations (Fankhauser et al., 2016). Significantly, these two literatures are complementary and collectively provide greater insight than each separately. These two strands are further supplemented by studies focusing on the local, sub-national level (Jänicke, 2017; Jörgensen et al., 2015; Liu et al., 2013) and the role of non-state actors (Bäckstrand et al., 2017; S. Chan et al., 2015; Sander Chan et al., 2018; Hale, 2016) – both important areas of research, but which remain outside the scope of this paper.

This paper seeks to contribute to the literature in the second category of multi-country studies by undertaking a comprehensive survey of climate action for mitigation purposes up to May 2017. The wide range of such studies (some compared in Table 2.1) collectively provide a kaleidoscopic overview of how policy-making for climate mitigation has slowly but steadily expanded as a key part of national planning. For taxonomic purposes, multi-country studies are usefully divided into two further categories, based on whether they are evaluative or comprehensive.

The evaluative category focuses on a relatively small group of countries, enabling them to assess both prevalence and stringency of climate action in national policies or NDCs. These studies typically concentrate on major emitters whose pledges or performances are ranked or rated using a variety of approaches, including composite indices, projections, case studies, and qualitative interviews (Averchenkova & Bassi, 2016; Burck et al., 2017; CAT, 2016).[2] For example, Averchenkova & Bassi (2016) assess the credibility of G20 countries' NDC pledges, and hence, study stringency by using both qualitative and quantitative indicators across four parameters. Climate Action Tracker (2016) estimates future emissions resulting from national policies for 32 countries and benchmarks performance against global targets. By comparing countries performance, these studies aim to identify climate leaders and laggards.

The comprehensive category of studies, of which this paper is a part, seeks to focus on breadth across countries, providing a comprehensive look at the spread of climate action. These efforts do not rank or rate countries performance, but rather examine the prevalence of climate action, without evaluating their stringency. While this allows them to steer clear of subjective metrics, it limits them to documentation rather than evaluation. These studies vary in their emphasis and source material - some focus on legislation while others, including this study, also look at specific sectors (GRI, 2017). Most give prominence to domestic data sources (Nachmany et al., 2017) while others, such as WRI-CAIT, limit themselves to international sources (WRI, 2017). They all seek to cover a large swathe of countries, ranging, in the examples cited above, from 164 to 194 nations.

This literature has expanded greatly in the last five years. In particular, the documentation of climate action has become more systematic. For example, the repository of climate change laws of the world (Nachmany et al., 2017) is comprehensive in its coverage of countries and climate laws. The Climate Policy Database[3], which was used as a collection tool for this study, includes a comprehensive overview of policies of selected countries. Moreover, the introduction of NDCs has created a database of national actions, although these do not, as yet, follow a common template.

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2 Another example is the Allianz Climate and Energy Monitor which focuses exclusively on renewable electricity policies https://newclimate.org/2017/06/29/allianz-climate-and-energy-monitor-2017/.

3 Climate Policy Database, https://www.climatepolicydatabase.org/ (Maintained by NewClimate Institute with support from PBL Netherlands Environmental Assessment Agency and Wageningen University and Research).

Table 2.1 Overview of efforts to track national climate policy

Study	Germanwatch Climate Change Performance Index (2017)	CAT NDC Assessment (2017)	Grantham: Beyond the targets (2016)
Central question	How do countries compare on their climate change performance in relative terms?	What are the effects of current domestic climate policy and INDC initiatives for future emissions and overall levels of warming?	How credible are the countries INDC pledges?
Method	Assessment based on a composite index composed of emission levels, development of emissions, current and projected levels of renewable energy and energy use, and global and national climate policy; quantitative data are supplemented with expert interviews	Mixed-method analysis combining historical data and comparable cases to model policy implementation and effect on emissions for each country	Assessing the policy credibility of a country's INDC based on a set of qualitative and quantitative indicators and information
No. of countries studied	56 and European Union (EU)	32	G20 including EU
Scope	Recent trend and level of: GHG emissions, renewable energy penetration, energy use , national and international climate policy	NDC commitment as part of the Paris Agreement and its national implementation	INDCs commitment as part of the Paris Accords of the G20 countries
Assessment of stringency	Yes	Yes	Indirectly assessed by means of credibility
Benchmarked against global targets	Partly	Yes	No
Basis for categorization	Ranking based on index score	Rating against a broad literature review of quantitative evaluations complemented by own analysis of what could be considered a "fair" contribution to the 2°C/1.5°C limit.	Rules and procedures, Players and organisations, Norms and public opinion, and Past performance (in meeting international commitments and domestic policies)
Source	Burck et al., 2017	CAT, 2016	Averchenkova & Bassi, 2016

4 The Climate Change Laws of the World Database is continuously updated. At the time when this study was conducted, it covered 164 countries. Since then it has expanded to global coverage (197 countries) in early 2018.

WRI CAIT Climate Data Explorer INDC Dashboard (updated 2017)	Climate Change Laws of the World Database (2017)[4]	Our approach (this analysis and Dubash et al. 2014)
What information is provided by countries on mitigation through their INDCs?	What domestic climate change or climate change relevant legislation (laws and policies) exist for 164 countries?	What national framework of climate legislation and policy is in place and how it has evolved between 2007 and 2017?
Assessment of national GHG mitigation contributions based on INDC using maps	Database of legislation, executive orders, and litigation pertaining to climate or climate-related topical areas (deforestation, overfishing, etc.) in countries for assessing global legislative trends	Survey of all the UN member states and categorization of national climate action based primarily on official government websites.
191 countries represented by 164 INDCs	164	194
NDC information: Mitigation contribution type, GHG target type, level of reduction commitment, GHG emission levels	All national-level climate change-related legislation, executive orders and litigation, defined widely	National climate legislation and strategy
No	No	No
No	No	No
Information provided in the INDCs	Collation of climate change legislation (laws and policies) in countries to develop a database on approach, legislative and executive portfolio, litigation and legislative process	Each country categorized as either (1) national climate legislation; or (2) national climate strategy and coordinating body; (3) neither of the above; or (4) analysis incomplete.
WRI, 2017	GRI, 2017; Nachmany et al., 2017	Dubash et al., 2014

The global regime is currently moving toward common frameworks for assessment of NDC implementation. Having such frameworks could provide avenues for conducting uniform comparisons across many countries, thus improving the reliability of findings. Nevertheless, as of now, studying the spread of legislation, strategies, targets and other such forms of climate action remains one of the most reliable means to assess the propagation and performance of mitigation efforts.

2.3 Rationale, approach and methods

The approach used in this paper complements existing literature. Firstly, it seeks to be comprehensive across all Parties to the UNFCCC. However, unlike other such comprehensive studies (GRI, 2017; WRI, 2017) this study relies on *domestic* sources for national climate legislation and strategy (targets are drawn from a mix of international and domestic sources, as discussed below). This approach allows this study to be comprehensive, as well as to focus on domestic action, rather than international statements of intent alone. Secondly, unlike another widely used study of legislation (GRI, 2017), this study uniquely examines national executive strategies by privileging the presence of a coordinating body. While legislative approaches are binding in nature, executive approaches are non-binding. Presence of a coordinating body emphasizes the commitment towards policy pronouncements in the latter cases, thus capturing the significant effect that non-binding strategies have also had on national action. Thirdly, this study includes national legislation, GHG targets, and renewable energy and energy efficiency targets, providing a larger scope than other studies. Finally, the output data is displayed against a range of different parameters, including number of countries, proportion of emissions, and proportion of global population, while taking account of regional variations. Notably, showing the adoption of assessed indicators in terms of population coverage is unusual in the literature, but important as larger populations, especially from developing countries, will drive future economic activity and related emissions. In 2015, non-Annex-I countries included in this study accounted for 82% of global population, but only 61% of global GHG emissions (based on data used in this study – see below).

Consequently, this paper provides an authoritative compilation of various forms of climate action, albeit without assessing their stringency or effect. The value of doing so is that the existence of such efforts, in addition to potentially demonstrating compliance with international pledges, can play an important role in creating conditions for mitigation actions on the ground through three pathways: spurring policy formulation, providing a basis for mainstreaming climate objectives into broader policymaking; and becoming a focal point for the efforts of national actors such as, policy-makers, administrators, NGOs and the private sector. In brief, while the existence of climate legislation and strategy may not be sufficient for enhanced mitigation action – in fact global GHG emissions are still rising – it is highly likely to create enabling conditions for such action, and thereby enhance its likelihood. This logic informs both the earlier 2013 study and this paper. Notably, this approach contributes an important component to the understanding of domestic climate action. Complementary studies could include stringency and performance assessments of existing actions, and case studies on the causal dynamics through which those actions are established and have effect (Averchenkova & Bassi, 2016; Burck et al., 2017; CAT, 2016). In addition, studies of sub-national scale action and role of non-state actors are likely to grow in importance. Indeed, as climate actions mature and move to the implementation stage, the emphasis should increasingly shift to evaluative studies, including at sub-national levels. However, at this early stage of climate action formulation, a comprehensive review, such as is attempted here, is an important starting point.

The methods in this paper are designed to avoid normative judgements and are based on clear decision rules and guidelines for categorization. They also deliberately follow and extend the approach undertaken in Dubash et al. (2014) to enable consistency across time periods.[5] The country scope includes almost all Parties to the UNFCCC.[6] The paper was extended to include GHG targets, renewable energy and electricity targets, and energy efficiency targets. The rationale for assessing energy related targets (renewable and energy efficiency) aside from GHG emissions targets, was not only that these are the most commonly used targets in climate mitigation, but also that energy production and consumption are the major sources of GHG emissions. Furthermore, while we recognize that agriculture and forestry specific targets, such as halting deforestation, would play a key role in countries such as Indonesia or Brazil, these targets would be less relevant for countries with little to no forests and agricultural production.

To categorize climate legislation and strategy, the following coding system (Figure 2.1) was used: (1) if a country has climate legislation or legislative targets (passed by

5 Two changes were made from the earlier paper. First, the representations in this paper follow United Nations regional categories rather than IPCC categories, because they allow more fine-grained discussion of regional differences. In particular, placing Middle East and Africa in one category obscured potentially relevant trends. Compared to the previous study, this paper includes all previous countries, except Greenland, and adds Cook Islands and Niue (that are not UN members, but are Parties to the UNFCCC).

6 The coverage includes all Parties to the UNFCCC, except South Sudan and Palestine, two Parties that joined the Convention after the end of the first assessed period of this study (2007-2012). The European Union is also excluded as a Party, but its climate action is reflected under the individual member states.

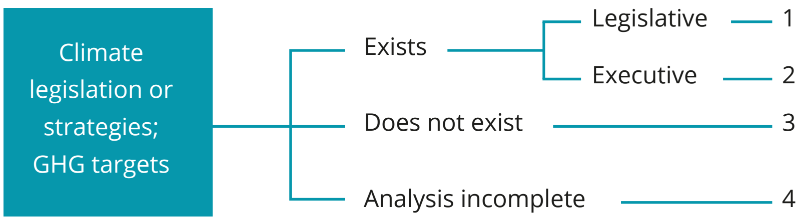

Figure 2.1 Summary of country categorization approach.

the Parliament or equivalent body with legislative power); (2) if a country has climate strategies or executive targets (not passed as law, but only as a measure/policy at the governmental/ministerial level). Here, an additional requirement for executive climate strategies (not for targets) to qualify is the existence of a designated coordination body to indicate implementation intent; (3) if a country has no such legislation, strategy or target; and (4) if the assessment could not be performed due to unavailability of official documents or translations in a language accessible to the team, or a lack of coverage by most comprehensive databases. Figure 2.1 shows a summary of this methodological approach. We include a coordination body in (2) to separate it from a political statement of intent, but not in (1) as we assume that legislation includes provisions for institutional coordination. For further details on categorisations of each indicator, please consult Supplementary Material for Chapter 2 (SM2.1).

To perform the country categorisation, existing policy databases and the UNFCCC National Communications were first verified. In addition to these sources, official government websites were analysed, where possible, and a thorough internet search was performed, using specific keywords in English, but also Spanish and French, when suitable. A complete list of the major databases used is provided in the Supplementary Material for Chapter 2 (SM2.2).

We assessed official documents of strategies and legislation in detail to determine their comprehensiveness and suitability. If external databases mentioned the existence of a legislation or strategy, but we did not find the original or translated document of this measure, the respective countries were scored 4 (analysis incomplete). Targets (GHG, renewables and energy efficiency) were taken into account whenever they were defined in a policy or law, regardless of its general comprehensiveness. All overarching GHG emissions targets were included, whether defined in terms of absolute emissions, emissions intensity, or other metrics, and the same holds true for renewables and energy efficiency targets which were defined as shares of energy production or consumption, total saved energy, renewables installed capacity or otherwise. Additionally, targets for 'non-fossil fuels', 'clean energy' or 'indigenous sources' were included as these are likely to be covered partly by renewables. Targets formulated as political statements were not counted if not included in a policy or law. In terms of international pledges, GHG emissions targets under the Kyoto Protocol were included as legislative targets, due to their legally-binding nature. Furthermore, all types of targets in the NDCs were included as executive targets, as these are nationally determined and adopted through the Paris Agreement, but not legally-binding. No other international pledges were included. Country-specific sources and additional detail on strategies, legislation and targets can be found in Excel format in the Supplementary Material of this chapter's published version (Iacobuta et al., 2018).

GHG emissions targets were included only if they covered at least the energy sector and at least CO_2 emissions. However, in most countries, these targets had an overarching coverage of sectors, including Land-Use, Land-Use Change and Forestry (LULUCF). Furthermore, we counted energy efficiency targets only when these targets covered all sectors. However, given the high potential for renewables in the electricity sector specifically, targets for renewables that only cover electricity generation or consumption were included. While energy efficiency targets were counted only when defined with an economy-wide coverage, we acknowledge that such targets are often set on a sectoral level and hence this category is likely to only yield partial coverage.

Only policies and targets available online by May 2017 (data collection cut-off date) were included. Furthermore, for each cut-off year (2007, 2012 and 2017) only policies and targets that continued to be in place at the end of the assessed year were accounted for.

Data on GHG emissions coverage was obtained using the PRIMAP database (Gütschow et al. 2017) with extrapolations. For strategies, legislation and GHG emissions targets the GHGs included under the 1997 Kyoto Protocol[7], including LULUCF, were used (PRIMAP category CAT0, KYOTOGHG). However, this study only accounts for the coverage of CO_2 emissions (PRIMAP, CAT0, CO_2) or energy-related emissions (PRIMAP, category CAT1, KYOTOGHG) when GHG emissions targets addressed only these areas specifically. Furthermore, renewable energy targets and energy efficiency targets were coun-

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7 Methane (CH4), Carbon dioxide (CO_2), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF6), Nitrous oxide (N2O).

ted as covering energy-related GHG emissions only (PRIMAP, CAT1, KYOTOGHG). For population coverage, United Nations Population Division data for total population[8] is used.

As this paper covers all four indicators starting from the year 2000, it also re-assessed climate strategies and legislation for 2007 and 2012 that were analysed in the earlier paper (Dubash et al., 2014), so as to account for improved data availability. Following this re-assessment, changes in scoring emerged for a small number of countries as follows: additional data allowed for the assessment of countries that were previously scored 4 (analysis incomplete); strategies that were introduced in or closer to 2012 but made available online in an accessible language at a later stage were only captured in this paper; new information could be retrieved from more recent sources such as the NDCs but could not be corroborated with official documents or respective translations (leading to scores of '4' for all years). The Excel file in the Supplementary Material of this chapter's published version (Iacobuta et al., 2018) transparently shows the scores of this manuscript next to those of the earlier manuscript (Dubash et al., 2014)its focus on national policies (rather than international pledges, as well as the rationale and sources used in each case.

We group the country results in geographical regions and differentiate by Annex-I and non-Annex-I countries, as defined in the UNFCCC and in the Kyoto Protocol. We include the Annex classification because doing so allows consistent comparison across time, which is also useful because the Paris Agreement makes consistent reference to 'developed' and 'developing' countries while avoiding the Annex based categories.

2.4 Results

The results are presented for three points in time – 2007, 2012, and 2017. This time interval captures key transition moments in the international climate policy debate. Thus, the analysis allows an examination of correlated national measures over these periods. The period from 2007 to 2012 (referred to as Period I) represents a period during which many developing countries, in particular, faced political pressure to develop national strategies in the build–up to the negotiations process around the

8 UN-DESA. (2017). Total population, both sexes – database. Retrieved from https://esa.un.org/unpd/wpp/DVD/Files/1_Indicators%20(Standard)/EXCEL_FILES/1_Population/WPP2017_POP_F01_1_TOTAL_POPULATION_BOTH_SEXES.xlsx

2009 Copenhagen COP. Period II, from 2012 to 2017, spans the Paris COP of 2015, in the run up to which most countries tabled pledges, subsequently labelled NDCs allowing various analyses of national measures related to NDCs. Here, the results for climate legislation or strategy, GHG emissions targets, renewable energy targets, and national energy efficiency targets are examined.

2.4.1 Climate legislation and strategy

By 2017, almost half of the assessed countries had put in place either climate legislation or strategies (Figure 2.2). The greatest increase in climate legislation or strategy, taken together, occurred during Period I, with only an incremental increase during Period II (Figure 2.3a). Over Period I, 21% of countries (41 countries) with climate legislation or strategy increased to 43% (82 countries). Over period II, this number only increased modestly to 49% (94 countries). Climate legislation, which represents a nationally binding measure, and is, therefore, harder to reverse than strategy or policy, only increased modestly from 16% to 21% to 24% over the ten-year period. More than 75% of Annex I Parties already had climate legislation in place in 2007, likely reflecting, in most cases, efforts to implement their legally binding targets under the Kyoto Protocol, which entered into force in 2005. There has also been a small but noticeable increase in non-Annex-I countries with climate legislation between 2012 and 2017. However, the greatest change is in climate strategies in non-Annex-I countries, particularly in Period I, but continuing in Period II.

Taken together, these data indicate that the period between 2007 and 2012 that included COP 15 in Copenhagen in 2009, and COP 16 in Cancun in 2010 represented a big step toward more widespread national measures, driven particularly by the uptake of climate strategies across the developing world. This trend has consolidated at a slower pace in Period II but, as we discuss below, Period II was more closely associated with the setting of targets around the Paris negotiations session.

While the number of countries with climate legislation or strategies in place by 2017 is limited (49%), the picture becomes more nuanced in terms of population and emissions covered (Figure 2.3b&c). For example, between 2007 and 2012, the adoption of legislation and strategies is far higher in terms of population and emissions coverage than the percentage of countries covered. This suggests that larger emitting nations are disproportionately represented among the early movers in terms of climate legislation and strategy. It also suggests that larger emitting nations were responding to political pressures prior to the Copenhagen conferences, a conclusion borne out by Figure 2.11 that displays the trend over time.

Understanding trends in terms of population and emissions are, also more encouraging than the picture in terms of number of countries alone. Both are, in some ways, a better metric for understanding climate change mitigation potential than the number of countries, since the first indicates the share of people globally whose economic activity is subject to climate policy, and the second directly focuses on the object of regulation (i.e. GHG emissions). Thus, 76% of the global population and 69% of total GHG emissions were covered by legislation or strategies by 2017, with legislation alone covering a substantial 36% of the population and 44% of emissions (Figure 2.3b&c).

When legislation and strategy are taken together, in non-Annex-I countries, 78% of the population and 77% of GHG emissions were covered by 2017, compared to 70% of the population and 55% of emissions in Annex-I countries. In addition, by 2017 while many more Annex-I countries had legislation in place, in emissions terms, a higher proportion of non-Annex I emissions were covered by climate legislation (48%) – most likely due to the disproportionate impact of China – than of Annex I emissions (38%). In population terms, the non-Annex I coverage by legislation drops to 33%, likely reflecting the role of India, which has a large population and a climate strategy in place, but not legislation. Finally, the population and emissions data reinforce the fact that the heyday of climate legislation and strategy, particularly in non-Annex-I countries, was Period I, with Annex-I countries likely taking steps prior to this period, and with relatively little additional coverage in Period II, a pattern that is broadly consistent with the regionally disaggregated data.

In addition to climate legislation and strategies, a wide spread of national GHG, renewables and energy efficiency targets can also be observed worldwide in 2017, with the vast majority of countries having at least one of these three types of targets in place (Figure 2.4, and Supplementary Material for Chapter 2 (SM2.3) for 2007 and 2012). The following sections analyse each of the three major climate change mitigation target types (GHG emissions, renewables and energy efficiency) in greater detail.

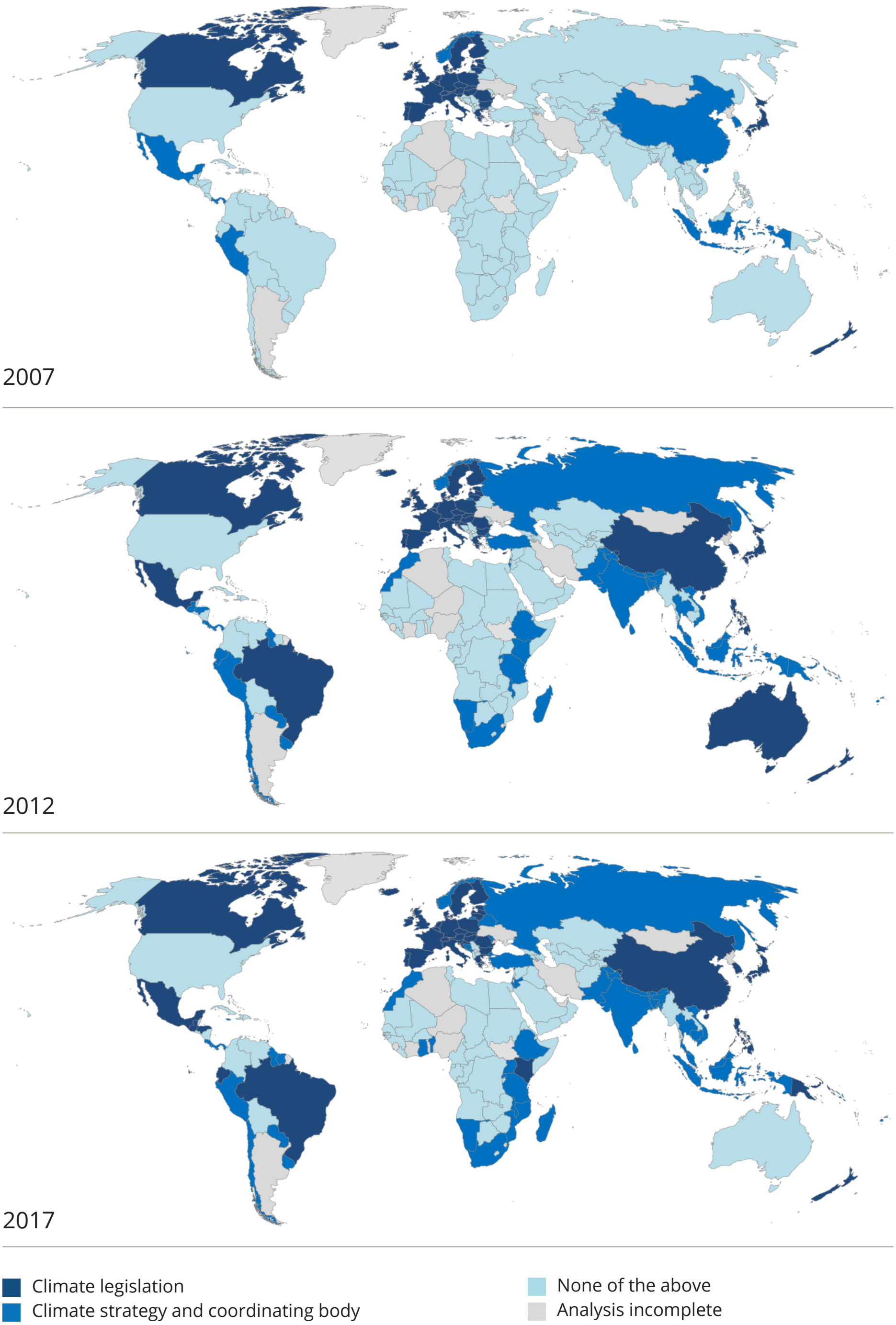
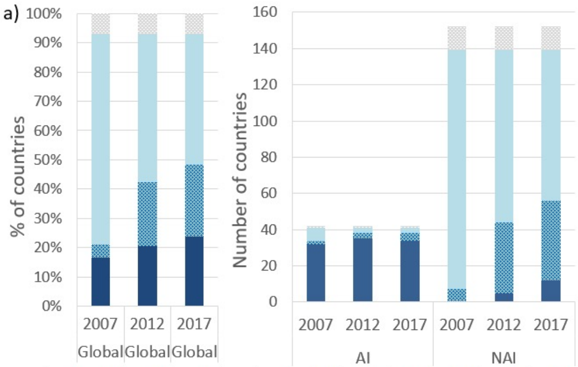


Figure 2.2 Climate legislation and strategies in 2007, 2012 and 2017.

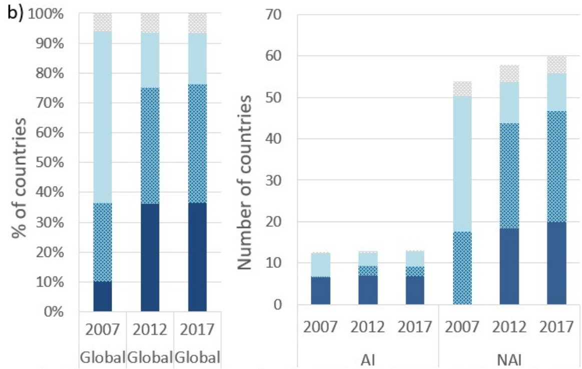
Figure 2.3 (a) Shares of countries with climate legislation and strategies; (b) Shares of population under climate legislations and strategies - in 2007, 2012 and 2017, and (c) Shares of GHG emissions under climate legislations and strategies - in 2007, 2012 and 2017. (The figure continues on the next page).

Note: AI = Annex-I countries; NAI = Non-Annex-I countries; AFR = Africa; ASIA = Asia; EUR = Europe (incl. Russia); NAM = North America; CSA = Central and South America; OCA = Oceania.



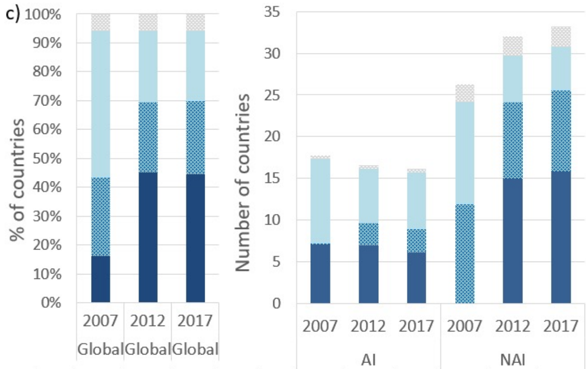
	2007 Global	2012 Global	2017 Global
1	32	40	46
2	9	42	48
3	139	98	86
4	14	14	14

	AI 2007	AI 2012	AI 2017	NAI 2007	NAI 2012	NAI 2017
1	76%	83%	81%	0%	3%	8%
2	5%	7%	10%	5%	26%	29%
3	17%	7%	7%	87%	63%	55%
4	2%	2%	2%	9%	9%	9%



	2007 Global	2012 Global	2017 Global
1	7	25	27
2	18	28	29
3	38	13	13
4	4	5	5

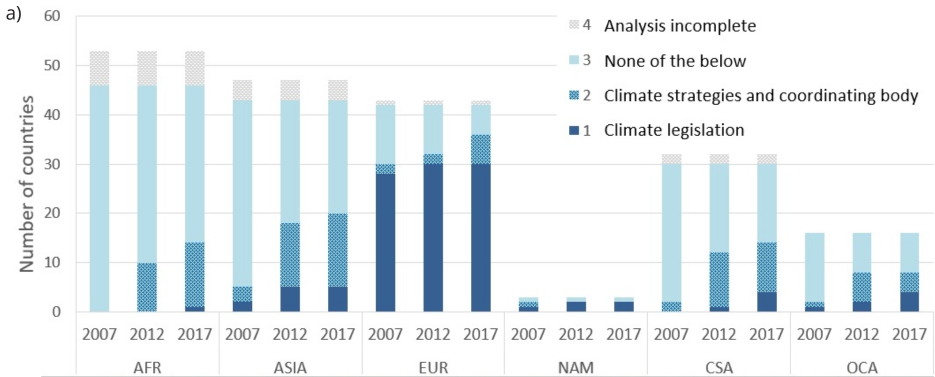
	AI 2007	AI 2012	AI 2017	NAI 2007	NAI 2012	NAI 2017
1	53%	54%	52%	0%	32%	33%
2	0%	17%	18%	33%	44%	45%
3	43%	25%	26%	60%	17%	15%
4	4%	3%	3%	7%	7%	7%



	2007 Global	2012 Global	2017 Global
1	7	22	22
2	12	12	13
3	22	12	12
4	3	3	3

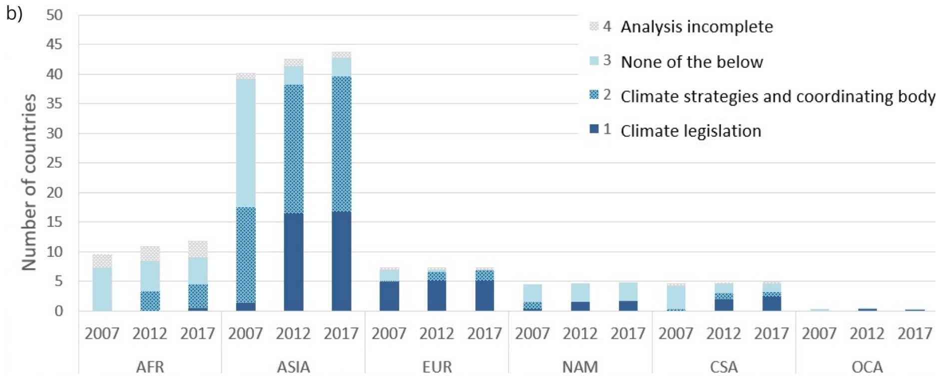
	AI 2007	AI 2012	AI 2017	NAI 2007	NAI 2012	NAI 2017
1	40%	42%	38%	0%	47%	48%
2	0%	16%	17%	45%	29%	29%
3	57%	40%	42%	47%	17%	16%
4	2%	2%	2%	8%	7%	7%

a)



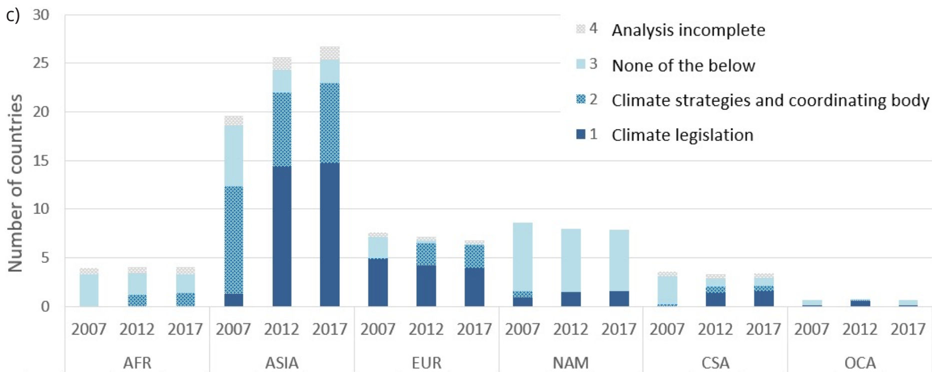
	AFR 2007	AFR 2012	AFR 2017	ASIA 2007	ASIA 2012	ASIA 2017	EUR 2007	EUR 2012	EUR 2017	NAM 2007	NAM 2012	NAM 2017	CSA 2007	CSA 2012	CSA 2017	OCA 2007	OCA 2012	OCA 2017
1	0%	0%	2%	4%	11%	11%	65%	70%	70%	33%	67%	67%	0%	3%	13%	6%	13%	25%
2	0%	19%	25%	6%	28%	32%	5%	5%	14%	33%	0%	0%	6%	34%	31%	6%	38%	25%
3	87%	68%	60%	81%	53%	49%	28%	23%	14%	33%	33%	33%	88%	56%	50%	88%	50%	50%
4	13%	13%	13%	9%	9%	9%	2%	2%	2%	0%	0%	0%	6%	6%	6%	0%	0%	0%

b)



	AFR 2007	AFR 2012	AFR 2017	ASIA 2007	ASIA 2012	ASIA 2017	EUR 2007	EUR 2012	EUR 2017	NAM 2007	NAM 2012	NAM 2017	CSA 2007	CSA 2012	CSA 2017	OCA 2007	OCA 2012	OCA 2017
1	0%	0%	4%	3%	39%	38%	68%	69%	70%	7%	33%	34%	0%	41%	49%	12%	74%	33%
2	0%	30%	34%	40%	51%	52%	1%	20%	23%	25%	0%	0%	7%	22%	15%	1%	25%	4%
3	76%	47%	38%	54%	7%	7%	25%	4%	2%	67%	67%	66%	84%	28%	27%	87%	1%	63%
4	24%	24%	24%	3%	3%	3%	6%	6%	6%	0%	0%	0%	9%	9%	9%	0%	0%	0%

c)



	AFR 2007	AFR 2012	AFR 2017	ASIA 2007	ASIA 2012	ASIA 2017	EUR 2007	EUR 2012	EUR 2017	NAM 2007	NAM 2012	NAM 2017	CSA 2007	CSA 2012	CSA 2017	OCA 2007	OCA 2012	OCA 2017
1	0%	0%	1%	6%	56%	55%	64%	59%	57%	11%	19%	20%	0%	41%	47%	9%	89%	22%
2	0%	29%	34%	56%	30%	31%	0%	32%	36%	7%	0%	0%	5%	21%	16%	0%	11%	0%
3	84%	54%	48%	32%	9%	9%	30%	3%	1%	82%	81%	80%	83%	25%	25%	91%	0%	78%
4	16%	17%	18%	5%	5%	5%	6%	6%	6%	0%	0%	0%	12%	13%	13%	0%	0%	0%

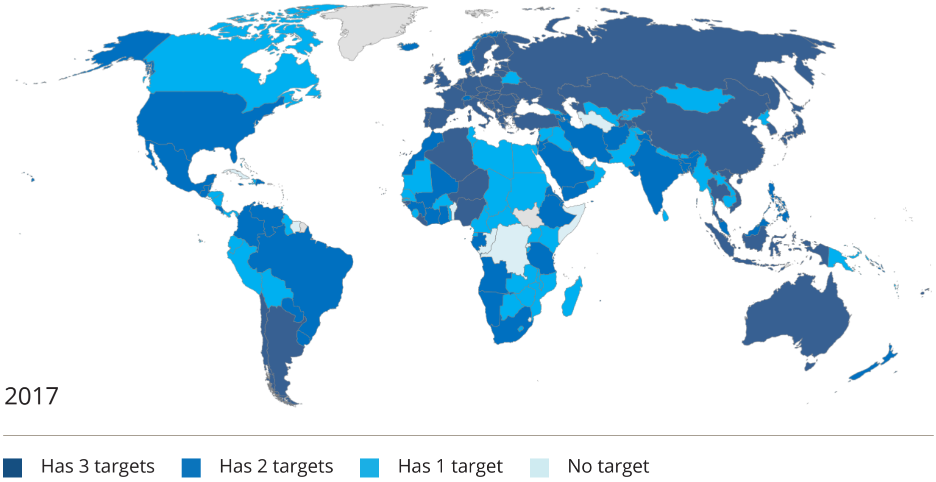


Figure 2.4 Number of target types (GHG, renewable and energy efficiency) in 2017. The number of targets in some countries might be higher as some could not be analysed (score 4). This figure is only indicative of the wide spread of targets worldwide.

2.4.2 Greenhouse gas targets

If Period I saw a dramatic increase in the number of countries putting in place climate legislation or strategy, Period II saw a correspondingly dramatic change in the articulation of GHG targets (Figure 2.5). This analysis does not examine the stringency or adequacy of targets or their form (absolute, intensity, or other) and only partially examines their durability (assuming that executive measures can more easily be removed by new governments, while laws are more durable, given that their removal requires the approval of the legislative body). Figure 2.5a shows that, by 2017, 76% of countries had put in place an emissions target – whether legislative or executive– compared with 23% in 2012, at the start of Period II, and to 20% in 2007, at the start of Period I. The substantial increase in Period II is predominantly in the form of executive rather than legislative targets – legislative targets increased only marginally from 22% to 23% of countries – likely as part of the formulation of NDCs that largely had executive targets.

Taken together, by 2017, these targets cover a substantial 91% of global population (dropping to 86% if USA's NDC target is excluded[9]) and 93% of all global emissions (dropping to 81% if USA's NDC target is excluded) (Figure 2.5b&c). While there was

9 The NDC of the USA, and hence its GHG target, is still counted here as existing in 2017 although the Trump Administration has announced its intent to withdraw from the Paris Agreement and cease implementation of its NDC, because the NDC is still valid until such time as this withdrawal takes effect according to the timelines enshrined in the Paris Agreement.

steady progress in Annex-I countries, 90% of which already had targets in place by 2007 going up to 100% (97% without USA's NDC target) in 2017, non-Annex-I countries saw a substantial jump, going from only 1% of countries having an emissions target in 2012, to 69% in 2017.

Annex-I countries continue to be more likely to have legislative rather than executive targets. Thus, while 90% of Annex-I countries' targets were enshrined in legislation by 2017, likely due to the adoption of the Kyoto Protocol, in non-Annex-I countries, only in 4% of the countries were these legislative while 65% were executive. However, in terms of population (28%) and GHG emissions (41%) covered, a much larger share of non-Annex I targets are legislative, reflecting the extent to which China's actions affect the global aggregate data.

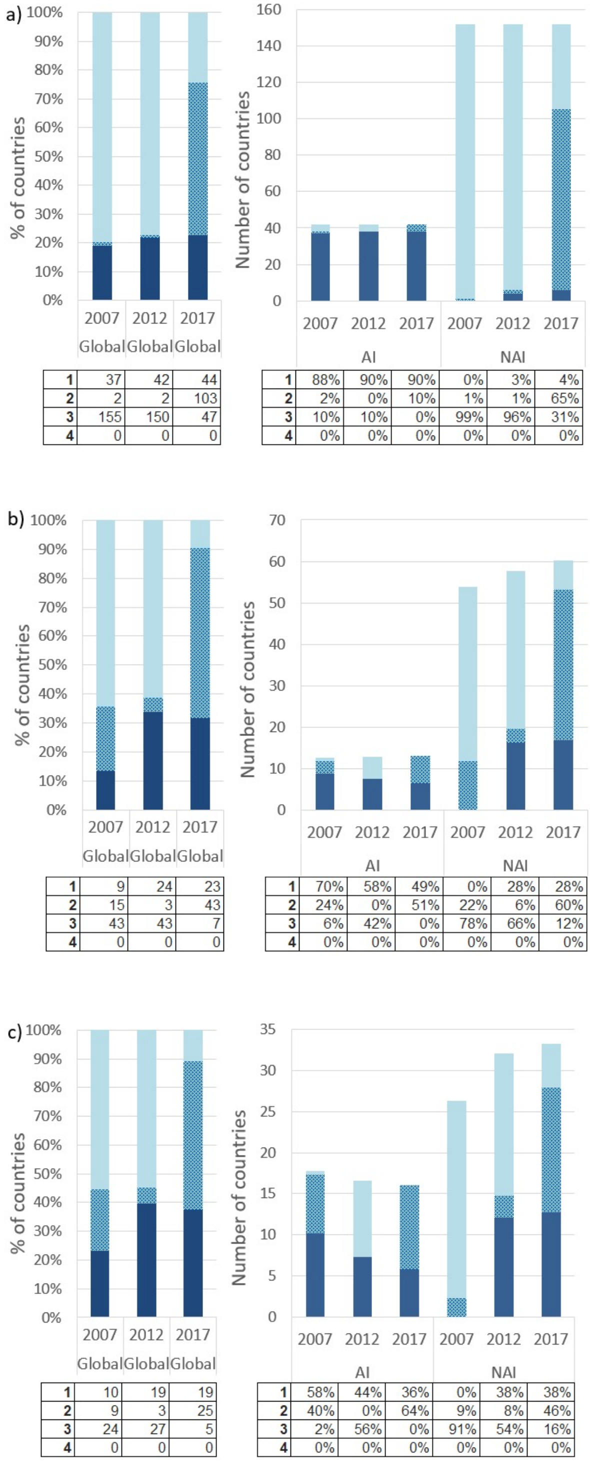
2.4.3 Renewable energy and electricity targets

The use of targets to accelerate a renewable energy transition is a useful, albeit partial, indicator of advancing climate policy. While the achievement of renewable targets requires additional supporting measures, such as feed-in tariffs and renewable portfolio standards, the targets themselves represent an indication of ambition and send clear messages to the relevant sectors. Thus, the spread of these targets provides a complementary perspective to the spread of climate legislation/strategy and GHG targets. As countries differ in their approaches, with some adopting renewable energy targets in the total energy mix and others in the electricity sector alone, here we took into consideration both types of targets.

As Figure 2.6a shows, 71% of countries had either legislative or executive renewable energy and/or electricity targets by 2017, with a steady rise from 20% in 2007. These targets are more commonly framed as executive action (44%) rather than legislative action (27%), with developed countries disproportionately accounting for legislative action. In 2017, 79% of Annex-I countries had legislative renewable energy targets, while only 13% of non-Annex-I countries had legislative targets. On a regional basis, Europe stands out as having the highest share of targets and particularly legislative targets.

As with the other indicators, the prevalence of targets is even higher when assessed in terms of population and emission shares (Figure 2.6b&c). By 2017, 87% of the global population lived in a country that adopted renewable energy and/or electricity target, and these jurisdictions accounted for 79% of emissions. Moreover, in population terms, non-Annex-I countries have a higher share of population covered by targets (90%) versus Annex-I countries (72%), although the share of legislative targets, which imply a greater degree of irreversibility, continue to be higher in Annex-I countries.

Figure 2.5 (a) Shares of countries with executive or legislative GHG emissions reduction target; (b) Shares of population under executive or legislative GHG emissions reduction target - in 2007, 2012 and 2017; and (c) Shares of GHG emissions under executive or legislative GHG emissions reduction target - in 2007, 2012 and 2017. (The figure continues on the next page).



a)

	2007 Global	2012 Global	2017 Global
1	37	42	44
2	2	2	103
3	155	150	47
4	0	0	0

	AI 2007	AI 2012	AI 2017	NAI 2007	NAI 2012	NAI 2017
1	88%	90%	90%	0%	3%	4%
2	2%	0%	10%	1%	1%	65%
3	10%	10%	0%	99%	96%	31%
4	0%	0%	0%	0%	0%	0%

b)

	2007 Global	2012 Global	2017 Global
1	9	24	23
2	15	3	43
3	43	43	7
4	0	0	0

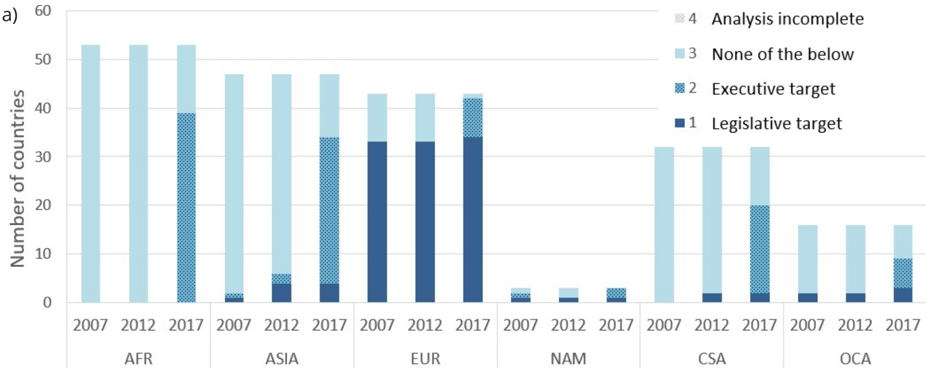
	AI 2007	AI 2012	AI 2017	NAI 2007	NAI 2012	NAI 2017
1	70%	58%	49%	0%	28%	28%
2	24%	0%	51%	22%	6%	60%
3	6%	42%	0%	78%	66%	12%
4	0%	0%	0%	0%	0%	0%

c)

	2007 Global	2012 Global	2017 Global
1	10	19	19
2	9	3	25
3	24	27	5
4	0	0	0

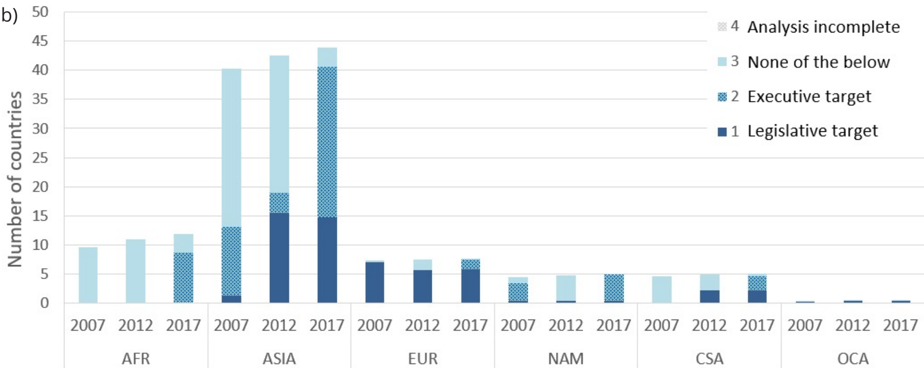
	AI 2007	AI 2012	AI 2017	NAI 2007	NAI 2012	NAI 2017
1	58%	44%	36%	0%	38%	38%
2	40%	0%	64%	9%	8%	46%
3	2%	56%	0%	91%	54%	16%
4	0%	0%	0%	0%	0%	0%

a)



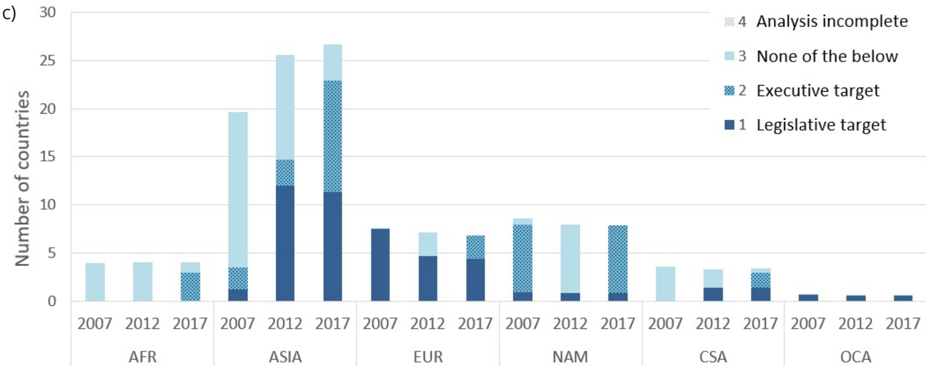
	AFR 2007	AFR 2012	AFR 2017	ASIA 2007	ASIA 2012	ASIA 2017	EUR 2007	EUR 2012	EUR 2017	NAM 2007	NAM 2012	NAM 2017	CSA 2007	CSA 2012	CSA 2017	OCA 2007	OCA 2012	OCA 2017
1	0%	0%	0%	2%	9%	9%	77%	77%	79%	33%	33%	33%	0%	6%	6%	13%	13%	19%
2	0%	0%	74%	2%	4%	64%	0%	0%	19%	33%	0%	67%	0%	0%	56%	0%	0%	38%
3	100%	100%	26%	96%	87%	28%	23%	23%	2%	33%	67%	0%	100%	94%	38%	88%	88%	44%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

b)



	AFR 2007	AFR 2012	AFR 2017	ASIA 2007	ASIA 2012	ASIA 2017	EUR 2007	EUR 2012	EUR 2017	NAM 2007	NAM 2012	NAM 2017	CSA 2007	CSA 2012	CSA 2017	OCA 2007	OCA 2012	OCA 2017
1	0%	0%	0%	3%	37%	33%	96%	76%	78%	7%	7%	7%	0%	43%	43%	74%	74%	73%
2	0%	0%	73%	29%	8%	59%	0%	0%	22%	67%	0%	93%	0%	0%	47%	0%	0%	5%
3	100%	100%	27%	67%	55%	7%	4%	24%	0%	25%	93%	0%	100%	57%	10%	26%	26%	22%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

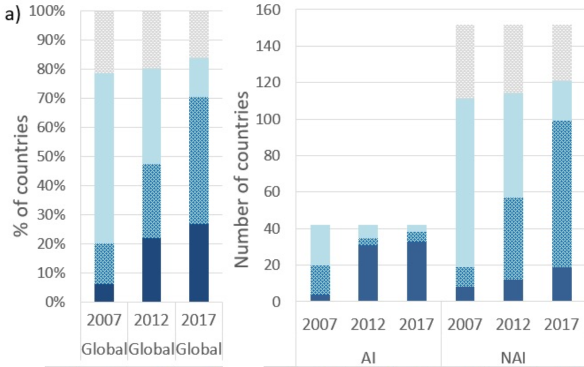
c)



	AFR 2007	AFR 2012	AFR 2017	ASIA 2007	ASIA 2012	ASIA 2017	EUR 2007	EUR 2012	EUR 2017	NAM 2007	NAM 2012	NAM 2017	CSA 2007	CSA 2012	CSA 2017	OCA 2007	OCA 2012	OCA 2017
1	0%	0%	0%	6%	47%	43%	98%	65%	65%	11%	10%	10%	0%	42%	42%	90%	89%	87%
2	0%	0%	73%	12%	10%	43%	0%	0%	35%	82%	0%	90%	0%	0%	44%	0%	0%	1%
3	100%	100%	27%	82%	43%	14%	2%	35%	0%	7%	90%	0%	100%	58%	14%	10%	11%	12%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Figure 2.6 (a) Shares of countries with executive or legislative renewables target in electricity or in the energy mix; (b) Shares of population under executive or legislative renewables target in electricity or in the energy mix – in 2007, 2012 and 2017; and (c) Shares of GHG emissions under executive or legislative renewables target in electricity or in the energy mix – in 2007, 2012 and 2017. (The figure continues on the next page).

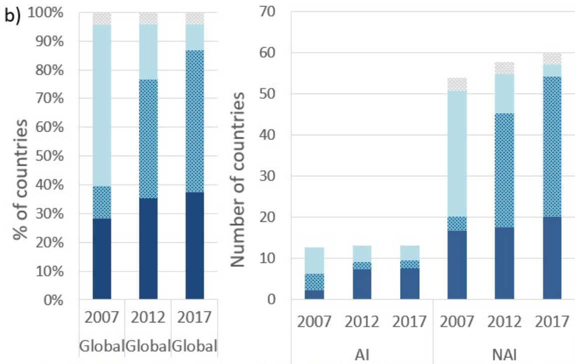
a)



1	12	43	52
2	27	49	85
3	114	64	26
4	41	38	31

1	10%	74%	79%	5%	8%	13%
2	38%	10%	12%	7%	30%	53%
3	52%	17%	10%	61%	38%	14%
4	0%	0%	0%	27%	25%	20%

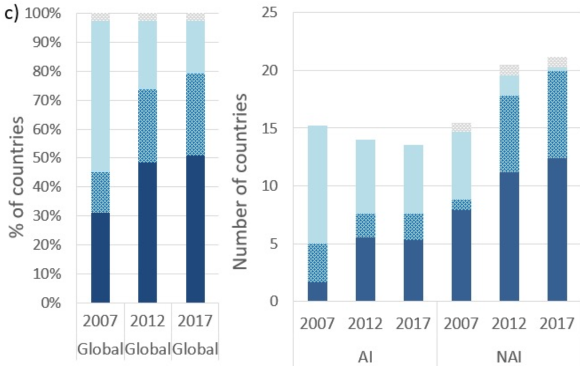
b)



1	19	25	28
2	7	29	36
3	37	14	7
4	3	3	3

1	18%	56%	57%	31%	30%	33%
2	31%	13%	15%	6%	48%	57%
3	51%	31%	28%	57%	17%	5%
4	0%	0%	0%	6%	5%	5%

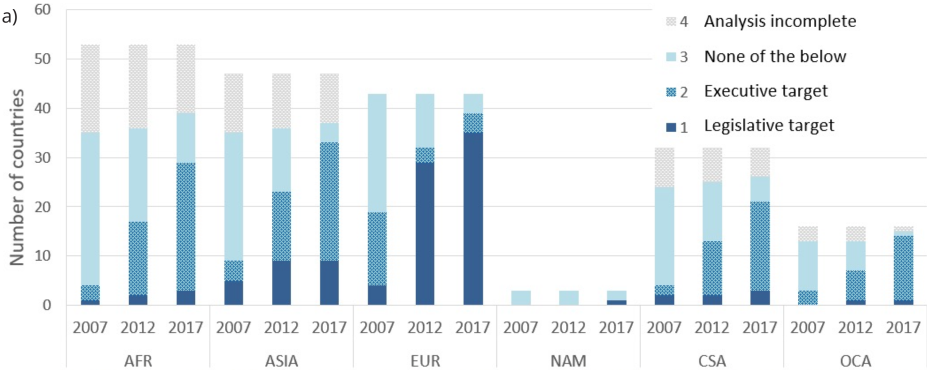
c)



1	10	17	18
2	4	9	10
3	16	8	6
4	1	1	1

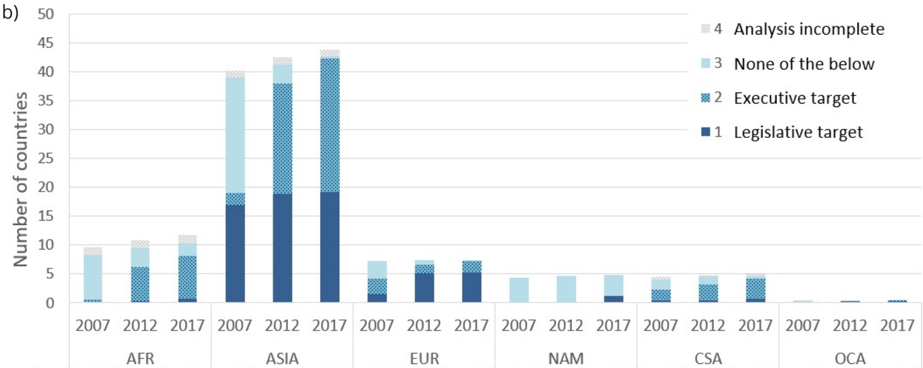
1	11%	40%	39%	51%	55%	58%
2	23%	14%	17%	6%	32%	36%
3	67%	46%	44%	38%	9%	2%
4	0%	0%	0%	5%	4%	4%

a)



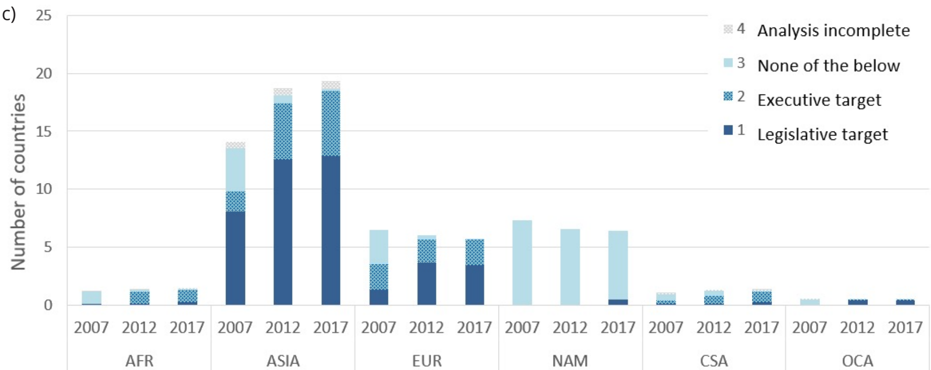
	AFR 2007	AFR 2012	AFR 2017	ASIA 2007	ASIA 2012	ASIA 2017	EUR 2007	EUR 2012	EUR 2017	NAM 2007	NAM 2012	NAM 2017	CSA 2007	CSA 2012	CSA 2017	OCA 2007	OCA 2012	OCA 2017
1	2%	4%	6%	11%	19%	19%	9%	67%	81%	0%	0%	33%	6%	6%	9%	0%	6%	6%
2	6%	28%	49%	9%	30%	51%	35%	7%	9%	0%	0%	0%	6%	34%	56%	19%	38%	81%
3	58%	36%	19%	55%	28%	9%	56%	26%	9%	100%	100%	67%	63%	38%	16%	63%	38%	6%
4	34%	32%	26%	26%	23%	21%	0%	0%	0%	0%	0%	0%	25%	22%	19%	19%	19%	6%

b)



	AFR 2007	AFR 2012	AFR 2017	ASIA 2007	ASIA 2012	ASIA 2017	EUR 2007	EUR 2012	EUR 2017	NAM 2007	NAM 2012	NAM 2017	CSA 2007	CSA 2012	CSA 2017	OCA 2007	OCA 2012	OCA 2017
1	1%	3%	6%	42%	44%	44%	21%	69%	72%	0%	0%	26%	8%	8%	14%	0%	62%	61%
2	6%	54%	63%	5%	45%	53%	36%	22%	27%	0%	0%	0%	43%	56%	70%	3%	15%	38%
3	80%	30%	18%	49%	8%	1%	43%	10%	1%	100%	100%	74%	38%	28%	8%	97%	23%	0%
4	13%	13%	12%	3%	3%	3%	0%	0%	0%	0%	0%	0%	11%	8%	8%	0%	0%	0%

c)



	AFR 2007	AFR 2012	AFR 2017	ASIA 2007	ASIA 2012	ASIA 2017	EUR 2007	EUR 2012	EUR 2017	NAM 2007	NAM 2012	NAM 2017	CSA 2007	CSA 2012	CSA 2017	OCA 2007	OCA 2012	OCA 2017
1	5%	6%	17%	57%	67%	66%	20%	60%	60%	0%	0%	8%	6%	6%	19%	0%	91%	91%
2	1%	75%	71%	13%	26%	29%	34%	33%	39%	0%	0%	0%	32%	56%	65%	0%	8%	9%
3	88%	13%	6%	26%	4%	1%	46%	7%	1%	100%	100%	92%	50%	30%	5%	100%	2%	0%
4	6%	6%	6%	4%	4%	3%	0%	0%	0%	0%	0%	0%	13%	9%	11%	0%	0%	0%

The high target adoption rate in non-Annex-I countries is particularly significant because most of these countries are likely to have growing future energy needs. For example, in 2017, 97% of the citizens of the populous Asian region lived in a jurisdiction with a renewable energy/electricity target, of which 44% were governed by legislation mandating a target.

The progress of renewable energy targets over time (Figure 2.7) shows a steady move toward legislative targets. While many countries move sequentially from no targets to executive targets through to legislative targets, a substantial share directly adopt legislative targets. Also, significantly, there are only very few cases of backsliding, either from legislative targets to executive targets or from either of these to no targets. This positive development coincides with the rapid reduction of costs in renewable energy in recent years. Similar diagrams for climate strategies and legislation and for GHG emissions targets can be found in Supplementary Material for Chapter 2 (SM2.3, Figure SM2.3 and Figure SM2.4), while such a diagram for energy efficiency is provided in the following section.

Finally, Figure 2.8 shows that renewable energy (93 countries) and electricity (105 countries) targets have been about as equally popular in 2017 (and in previous years), with a fairly large share of countries (61 countries) having both types of targets in place.

2.4.4 Energy efficiency targets

In addition to renewable energy, energy efficiency is another important area for addressing GHG emissions. In this section, we explore the spread of national energy efficiency targets. However, there are important caveats to this section. First, energy efficiency measures are frequently undertaken at sub-national scales, such as by states or provinces in federal jurisdictions or even cities, which are not represented here. Second, energy efficiency measures are often sector-specific, such as industry-specific targets or appliance-based policies, which again are not represented in a focus on national targets (Höhne et al., 2015). Consequently, this section may under-represent the prevalence of energy efficiency measures. Notably, the proportion of countries for which no information could be found is also much higher than in other assessed categories, at 56% (Figure 2.9a). However, this data is nonetheless worth exploring because the analysed sub-set of countries (44%) account for 77% of global population and 92% of emissions (Figure 2.9b&c).

By 2017, energy efficiency targets were adopted in 59 countries, which amounts to 69% of countries for which energy efficiency target data was available and 31% of total countries studied. Of the 31% of countries reporting energy efficiency targets

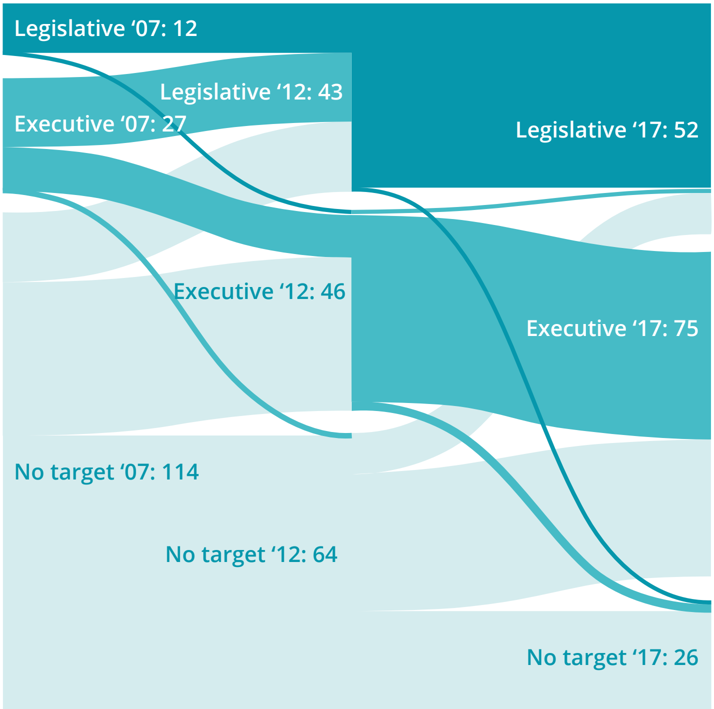


Figure 2.7 Number of countries changing between legislative, executive or no renewables target from 2007 to 2012 and 2017. The numbers represent the years and the number of countries in that category. Only countries that could be analysed (not scored 4) were included in this diagram (i.e. a total of 153 countries).

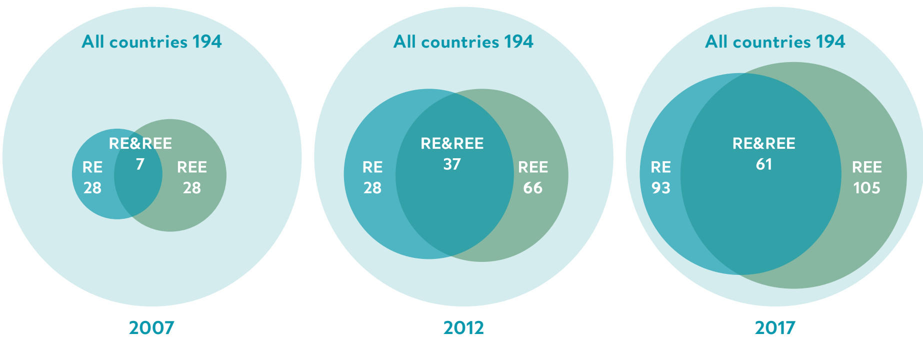
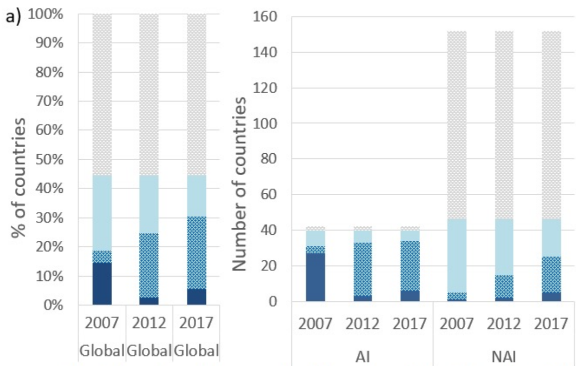


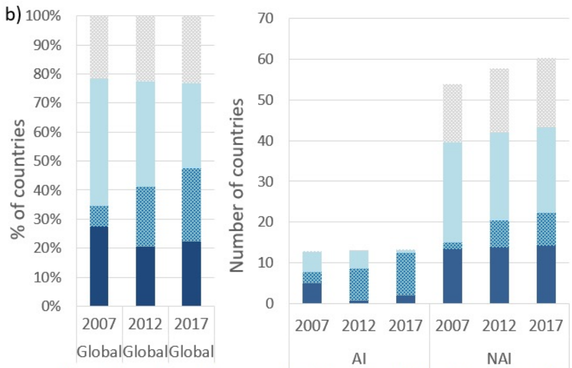
Figure 2.8 Circle sizes indicate the number of countries with renewable energy targets (RE, blue circle) and renewable electricity target (REE, green circle) out of the total number of countries assessed (light blue circle). The intersection between RE and REE circles shows the number of countries with both RE and REE targets.

Figure 2.9 (a) Shares of countries with executive or legislative energy efficiency target; (b) Shares of population under executive or legislative energy efficiency target – in 2007, 2012 and 2017; and (c) Shares of GHG emissions under energy efficiency target – in 2007, 2012 and 2017. (The figure continues on the next page).



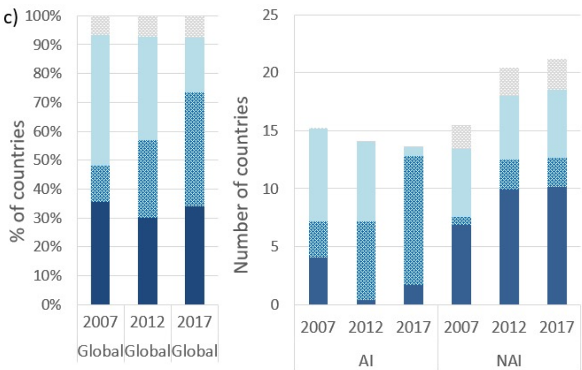
1	28	5	11
2	8	43	48
3	50	38	27
4	108	108	108

1	64%	7%	14%	1%	1%	3%
2	10%	71%	67%	3%	9%	13%
3	21%	17%	14%	27%	20%	14%
4	5%	5%	5%	70%	70%	70%



1	18	15	16
2	5	15	18
3	29	26	22
4	14	16	17

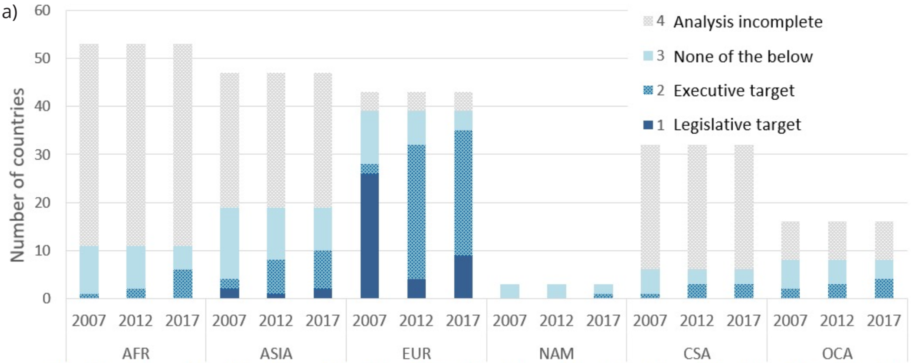
1	39%	6%	16%	25%	24%	24%
2	23%	61%	79%	3%	11%	13%
3	38%	33%	5%	45%	37%	35%
4	0%	0%	0%	27%	27%	28%



1	11	10	12
2	4	9	14
3	14	12	7
4	2	2	3

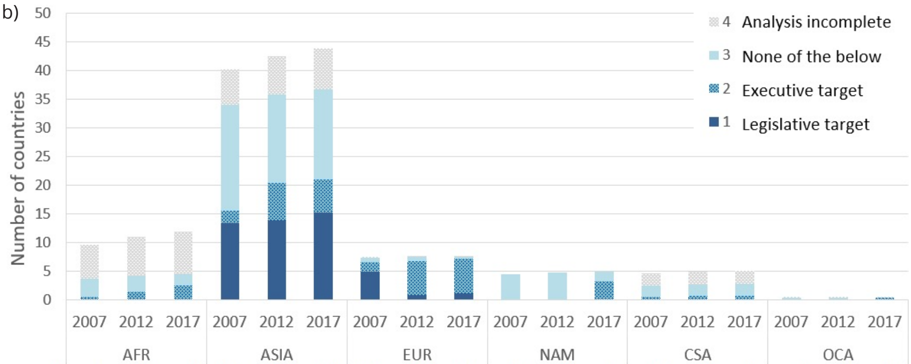
1	27%	3%	12%	44%	48%	48%
2	21%	48%	82%	4%	13%	12%
3	53%	49%	5%	38%	27%	28%
4	0%	0%	0%	13%	12%	12%

a)



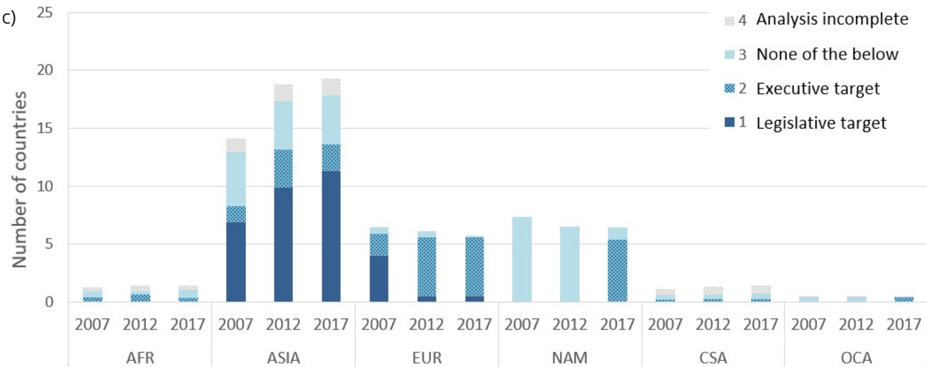
1	0%	0%	0%	4%	2%	4%	60%	9%	21%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	2%	4%	11%	4%	15%	17%	5%	65%	60%	0%	0%	33%	3%	9%	9%	13%	19%	25%
3	19%	17%	9%	32%	23%	19%	26%	16%	9%	100%	100%	67%	16%	9%	9%	38%	31%	25%
4	79%	79%	79%	60%	60%	60%	9%	9%	9%	0%	0%	0%	81%	81%	81%	50%	50%	50%

b)



1	0%	0%	0%	33%	32%	35%	67%	11%	14%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	5%	13%	21%	5%	16%	13%	21%	80%	83%	0%	0%	66%	9%	12%	12%	15%	15%	64%
3	33%	24%	16%	46%	36%	36%	12%	9%	3%	100%	100%	34%	45%	41%	41%	63%	62%	12%
4	62%	63%	63%	15%	16%	16%	0%	0%	0%	0%	0%	0%	46%	46%	47%	23%	23%	24%

c)



1	0%	0%	0%	49%	53%	59%	62%	8%	9%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	32%	46%	22%	10%	17%	12%	29%	85%	88%	0%	0%	84%	15%	19%	18%	8%	7%	91%
3	41%	24%	49%	33%	23%	22%	8%	7%	2%	100%	100%	16%	37%	33%	35%	90%	91%	7%
4	27%	29%	30%	8%	8%	8%	0%	0%	0%	0%	0%	0%	48%	47%	47%	2%	2%	2%

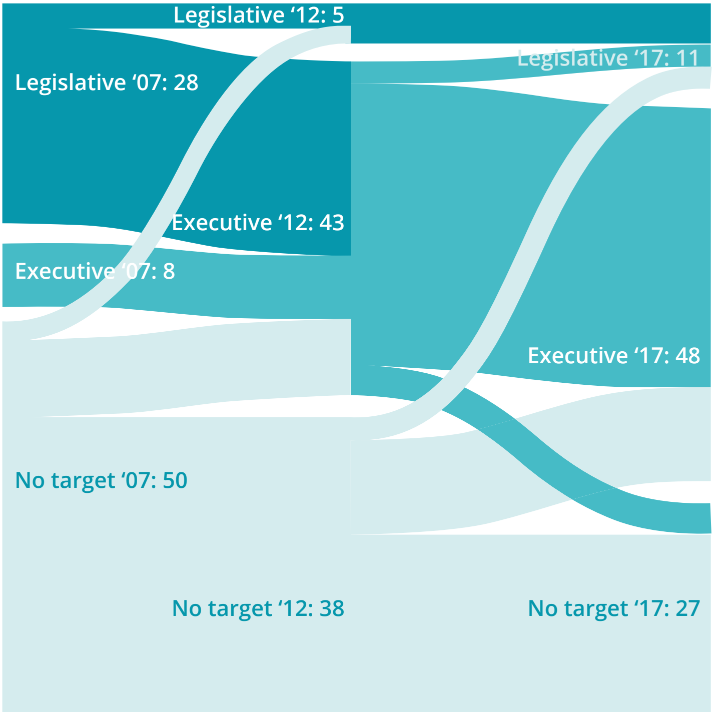


Figure 2.10 Number of countries changing between legislative, executive or no energy efficiency target from 2007 to 2012 and 2017. The numbers represent the years and the number of countries in that category. Only countries that could be analysed (not scored 4) were included in this diagram (i.e. a total of 86 countries).

in 2017, only 6% of countries reported legislative targets, a proportion which actually declined from 14% in 2007. This decline represents a shift from legislative to executive action in European countries between 2007 and 2012, before a partial reversal by 2017.

As in the case of other targets, the spread of energy efficiency targets by 2017 appears far greater when viewed in terms of population and emissions, with a coverage of 47% of total population and 73% of total emissions. These results indicate that larger emitter countries are more likely to have adopted energy efficiency targets. Furthermore, separation by Annexes also shows a high global coverage of energy efficiency targets: 94% of GHG emissions in Annex-I countries and 60% in non-Annex-I countries.

Figure 2.10 shows that energy efficiency targets do not follow a linear trajectory from no target through executive target to legislative target. Indeed, in a substantial share of countries, legislative targets have given way to executive targets or have even been removed altogether.

2.4.5 Trends over time: What was the likely impact of the UNFCCC process?

Finally, we look at annual developments in national strategies, legislation and targets since 2000 (Figure 2.11 and Figure 2.12). First, we observe a steep increase in the emissions under climate legislation and strategy, prior to the Copenhagen Accord of 2009. Notably this trend does not appear in Figure 2.12 representing the number of countries, suggesting that legislation and strategy in large non-Annex I emitters, perhaps in response to political pressures in the build-up to Copenhagen, are responsible for this increase. As discussed earlier (Figure 2.3), Annex-I countries had already adopted legislation and strategies prior to this period, likely in response to the adoption of the Kyoto Protocol (Figure SM2.4 and Figure SM2.5 in Supplementary Material of Chapter 2 show Annex-based trends). These results suggest that international efforts have broadened participation in climate action.

In addition, several trends are likely driven by key decisions of particular countries and regions. Thus, energy efficiency targets made a leap, when the EU adopted such targets in 2005, while emission coverage of renewable energy targets jumped in 2006 due to China adopting such a target for the first time. The United States also has a discernible influence on global emissions coverage, creating a drop in GHG target coverage in 2012 (when the old target expired and a new target was not yet adopted), and with the adoption of the Obama Climate Action Plan in 2013 and its repeal by the Trump Administration in 2017 (Footnote 10).

At the beginning of the millennium, all four indicators started from a similar level, below 10% country coverage, except legislation/strategies (15%), but by 2017, their uptake has varied in terms of number of countries, indicating that renewables and GHG targets are the most preferred instruments (adopted by more than 70% of countries), while energy efficiency had the least traction at a national level (only 31% of countries) (as discussed above, this may be because energy efficiency targets are often set sectorally or locally, which is not captured here, and because the share of assessed countries for this indicator was low itself, 56%). The likelihood that these targets will be met may be substantially lower in those countries where a climate strategy or legislation is not yet in place. However, the development of NDCs up to Paris may have led to follow-up processes for climate strategies and legislations that have not yet been finalized, so that the number of countries with strategies and

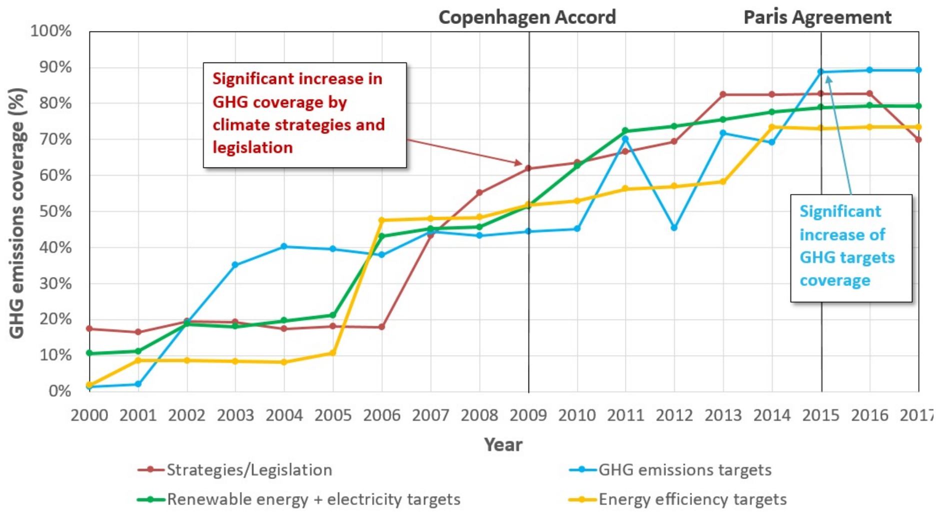


Figure 2.11 GHG emissions coverage by climate strategies, legislation and targets over total GHG emissions or only energy emissions (for renewables and energy efficiency targets) in the period 2000 to 2017.

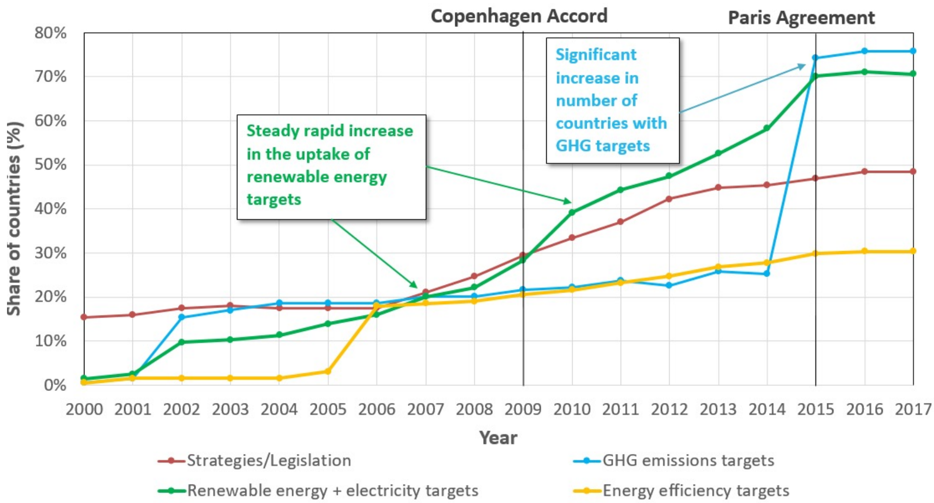


Figure 2.12 Share of countries with strategies, legislation and GHG emissions, renewables and energy efficiency targets in the period 2000 to 2017.

legislation in place may equal or exceed those with GHG emissions targets in the upcoming years.

2.5 Conclusions

This analysis presents the most comprehensive survey to date – across both time and space – of national climate legislation and strategies, and GHG, renewable energy and energy efficiency targets, covering developments since 2000 in 194 countries that are parties to the UNFCCC. This paper tracks the prevalence of the strategies and targets but does not assess their implementation or stringency. Tracking prevalence of these initiatives is important, as they are likely essential in laying the foundation for mitigation action. While legislation, strategies and targets may not be sufficient for implementation, they are likely necessary. Key conclusions include:

- By 2017, 69% of global GHG emissions (76% of the population and 49% of countries) are covered with either nationally binding climate legislation or climate strategies with a coordinating body. The increase coincides with the build-up to the Copenhagen Accord in 2009 and the share has not substantially increased since then;
- 93% of global GHG emissions (81% without USA), (91% of global population (86% without USA) and 76% of countries (75% without USA) are today covered with national GHG emissions targets with a strong increase in 2015 from the development of NDCs under the Paris Agreement. This is a steep increase from a global GHG emissions coverage of 69% and a country coverage of 25% in 2014 (just before the Paris Agreement);
- Renewable energy targets saw a steady increase from 40% in 2007 to 87% of the population and 79% of emissions in 2017, with a particularly steep increase witnessed during the last few years in developing countries. This coincides with the rapidly falling costs of renewable energy; and
- Key shifts in national measures coincide with landmark international events – an increase in legislation and strategy around the Copenhagen climate COP and an increase in targets around the Paris climate COP – emphasizing the importance of the international process to maintaining national momentum.

We conclude that international processes have an important role to play in stimulating or enabling national action. The exact dynamic between these two levels is a subject for further study and may well vary by country: in some contexts, national action may be spurred by international negotiations; in others, national consensus may enable more ambitious international pledges, thereby creating the conditions for enhanced global collective action. In either case, this iterative dynamic between international and national policy–making processes has contributed to almost global coverage of national climate policies and targets. This underlines the importance of generating momentum in preparation towards such future key moments, for example, through the Talanoa Dialogue in 2018 or the global stocktake in 2023.

Furthermore, repeating the analysis performed in this study in the future would help follow the evolution of climate action in particular in developing countries. Although developed countries currently have a relatively high coverage of all four indicators in our analysis, developing countries have yet to reach a ceiling, while their population, economic activity and related GHG emissions are likely to cover a much larger share in the future. More importantly, given the substantial coverage of climate strategies and targets, now is the moment to ensure *effective implementation* of these strategies and targets. Indeed, the continued rise in annual GHG emissions suggests that even if an increase in national legislation, strategies and targets are a necessary condition for falling emissions, they are not sufficient. Correspondingly, future research and analysis is necessary on the stringency of the policies and targets and their actual implementation, as well as on country-specific case studies of how climate action – comprising of legislation, strategy and target – shapes outcomes.

Heavy rains and melting glaciers cause strong floods and land erosion along riverbanks. Photo taken in Singpur, Bangladesh, 2013.

Increased temperatures lead to expanded areas of vector-borne diseases, such as malaria. Photo taken in Manu National Park, Peru, 2011.

3

What enables countries to set high greenhouse gas reduction targets?

A comparison of initial and updated Nationally Determined Contributions

This chapter is based on:

Iacobuta, G., Höhne, N. *What enables countries to set high greenhouse gas reduction targets? A comparison of initial and updated Nationally Determined Contributions.* (Submitted for publication)

Abstract

Through the Paris Agreement, countries agreed to make the necessary efforts to keep global mean temperature increase well below 2°C above pre-industrial levels and strive for 1.5°C. Yet, as individual pledges currently fall short of this commitment, ratcheting up ambition is urgently needed. In this study, we standardize and compare greenhouse-gas emissions (GHGe) reduction targets in countries' initial and updated Nationally Determined Contributions (NDCs) to determine expected changes in their GHGe up to 2030. To better understand what likely compels countries to pledge higher GHGe reductions, we map GHGe targets against several indicators that reflect countries' capabilities and responsibility: Gross Domestic Product per capita (GDP/cap); historical and annual GHGe/cap; GHGe/GDP; trends in GHGe/cap and GDP/cap; fossil fuel dependence; and relevant international financial support received. We find that GDP/cap and historical and annual GHGe/cap correlate best to the level of pledged increase/decrease of GHGe/cap to 2030. While most updated NDCs reinforce this correlation relative to the original NDCs, some move away from it, for example, by pledging lower GHGe reductions than previously. We find no clear correlation of conditional targets with the receipt of climate finance and only a weak correlation with GHGe/GDP and dependence on fossil-fuel exports, which are both key to the technological and economic transitions. Most developed and developing countries pledge GHGe/cap that are above the global average required for a maximum 1.5°C, and even 2°C, temperature increase in 2030. Comparable information on countries' climate targets is essential to the Global Stocktake process of the Paris Agreement and to identifying role models among specific groups of countries. Comparability can facilitate mutual learning and dialogue, and enable the processes of soft reciprocity and peer pressure that both are essential to the Paris Agreement success. Our study supports the negotiations process and respective political dialogues by providing insights on varied country contexts and facilitating comparison of GHGe targets among countries with similar development contexts

3.1 Introduction

The Paris Agreement adoption at the end of 2015 is seen as a key achievement of international climate change governance (Höhne et al., 2017). This agreement managed to overcome deadlocks that hindered international climate negotiations for decades, and to involve all developed and developing countries in climate action. While previous approaches strongly relied on top-down targets with a focus on contributions from developed countries, the Paris Agreement adopted a hybrid approach that includes both bottom-up commitments and top-down goals. Under this Agreement, countries can define their own climate commitments, known as Nationally Determined Contributions (NDCs), but the overarching goal to limit global temperature increase to well below 2°C and to strive for a maximum 1.5°C increase, requires all countries to contribute sufficiently.

To date, countries pledges are still not meeting the Paris Agreement temperature target (Climate Action Tracker, 2021). Intended NDCs submitted under the Paris Agreement in 2015 were estimated to lead to a temperature increase of approximately 3°C (Höhne et al., 2020; Rogelj et al., 2016; UNEP, 2019a) and current national policies are unlikely to achieve set goals (Roelfsema et al., 2020). Yet, despite this gap between set goals and pledged action, less than half of all countries have submitted new NDCs between 2015 and the end of 2020[10], with only a few countries pledging more ambitious greenhouse-gas emissions (GHGe) targets[11]. The recurrent five-year Global Stocktake (Paris Agreement, 2015, Article 14) was set in place to iteratively raise ambition through a process that mostly relies on countries' understanding of their fair share and on peer pressure, soft reciprocity, and mutual learning, whereby emerging leaders of climate action inspire and support others to be more ambitious (Falkner, 2016; Winkler, 2020; Winkler et al., 2018). Yet, for these processes to work, transparency on (intended) climate action is essential (Romain Weikmans et al., 2020).

As it stands, the Paris Agreement does not foresee a mechanism to legally direct individual countries towards specific GHGe reductions. Although it highlights the need for fairness and equity, it does not provide guidelines on translating these principles into country pledges and leaves this open to further political debate and voluntary approaches. In the earlier years of international climate negotiations, the principle of 'Common but Differentiated Responsibility and Respective Capabilities'

10 NDC Registry: https://www4.unfccc.int/sites/ndcstaging/Pages/Home.aspx; Climate Watch NDC Tracker: https://www.climatewatchdata.org/2020-ndc-tracker

11 Climate Action Tracker Climate Targets Update Tracker: https://climateactiontracker.org/climate-target-update-tracker/

was translated into a requirement for large historic emitters alone (i.e. Annex-I countries) to undertake climate-mitigation action and for those who have the capability (i.e. Annex II countries) to support developing countries (i.e. Non-Annex-I countries) in taking climate action. Since the Copenhagen Accord and especially since the Paris Agreement, all countries are expected to contribute to climate action. Nevertheless, the differentiated responsibility and capability principle remains a guiding force in the Paris Agreement and many countries adopt a language of differentiation in their NDCs (Castro, 2020; Pauw et al., 2019).

Enabling comparison of countries' climate action in the context of respective capabilities and responsibilities and in a manner that supports identification of role models is essential for an effective Global Stocktake process that inspires more ambitious climate action and brings in needed knowledge (Milkoreit & Haapala, 2019). Understanding what country contexts enable higher reductions in GHGe per capita (GHGe/cap) can support better tailored provision of information in the negotiations process. For instance, countries' indication of fairness approaches in the NDCs has been assessed, but without an analysis of the alignment of NDC targets to stated fairness approaches (Winkler et al., 2018). Other studies compared targets of all countries, but are missing the detail of countries context that could explain why certain countries have higher GHGe-reduction targets than others (King & Van Den Bergh, 2019; Watson et al., 2019). Finally, recent literature (e.g. Aldy et al., 2017; Brown et al., 2018; Höhne et al., 2017; Holz et al., 2018; Pan et al., 2018; Robiou Du Pont et al., 2017; Robiou du Pont, 2017; Zimm & Nakicenovic, 2019) has also started to scope out comparisons of a few or groups of countries' NDC targets to assess fairness. While equity and fairness remain important topics in global climate negotiations and domestic implementation (Klinsky et al., 2017; Moellendorf, 2012), policy and technological innovation and leadership around the world are important global drivers of climate ambition and socio-economic transformational changes (Biedenkopf et al., 2017; Schwerhoff, 2016; Victor et al., 2019). Being able to identify high performers among countries of similar socio-economic contexts can enable a better exchange and mutual learning on policy and technology advances.

To address these knowledge gaps and to support the process of iteratively raising ambition of the Paris Agreement, we visualize countries' standardised conditional and unconditional initial and updated NDC GHGe-reduction targets relative to commonly-used environmental and socio-economic indicators of capability and responsibility. First, we take stock of initial and updated NDC GHGe-reductions targets to 2030 and translate them into standardized indicators to be able to compare them. This way, we can fill in an important literature gap by analysing improvements between initial and updated NDCs. Second, we ask the question whether the levels of pledged

GHGe reductions are correlated with countries' responsibility, based on their (historical) GHGe/cap, and with countries' capabilities, based on four key indicators: 1) Gross Domestic Product per capita (GDP/cap) to reflect economic capability; 2) GHGe intensity of the economy (GHGe/GDP) and fossil fuel dependence, to reflect technological and economic implications of the transition; 3) average growth rate of GDP/cap and GHGe/cap to reflect recent economic and emissions trends and correlations; and 4) international financial support received for climate mitigation, to link to countries' conditional targets and required international support. Finally, we reflect on our results and consider how future research and processes under the Paris Agreement could further enable comparability and discussions with the outlook of mutual learning and of stimulating ambition.

This mapping aims to allow each country to identify its position in relation to other countries and to enable the emergence of role models that can provide not only a moral incentive but also valuable knowledge and experience for others to step up ambition (Schwerhoff, 2016). This mapping additionally enables civil society to exercise its role as 'informal monitor of the Paris Agreement' and to pressure countries to take a more ambitious stance (Falkner, 2016; Kingston, 2019). Importantly, the comparison between initial and updated NDCs provides an indication of how the past five years since the adoption of the Paris Agreement and respective international negotiations affected countries' climate targets.

3.2 Standardization of GHGe-reduction targets

One key objective of this study was to standardise GHGe targets pledged in the NDCs for the year 2030, the set timeline for the current round of NDCs, to enable comparability. The literature shows that a variety of approaches can be applied to compare the ambition of GHGe targets, but only two approaches are able to define and capture past action unambiguously: reduction from 1990 levels, and time and level of peaking GHGe/cap (Höhne, et al., 2018). The latter is limited in scope to a few countries that define their targets in this way. Moreover, while 1990 is a crucial year for Annex-I countries, which still define ambitions based on this year, 1990 would misrepresent recent socio-economic, technological and GHGe developments across developed and developing countries. For instance, den Elzen et al. (2013) have shown that excluding historical GHGe between 2000-2010 would reduce the contribution of most emerging economies by up to 80% from 1850. On the other hand, they also highlight the importance of technological progress, which led to substantially less expensive emissions-reduction options in the present and recent past than in the distant past. Accounting for technological progress can lead to high reductions in the relative historical GHGe contribution of some developed countries and to some (20%-50%) increase in the relative contribution of developing countries (ibid.)

In this study, we show GHGe targets relative to 2010. Other years can be used for this comparison, for instance, 2015 or 2020 to reflect the Paris Agreement adoption and start of implementation, respectively. However, here we chose 2010 for several advantages. First, the year 2010 better reflects recent economic and technological changes that likely influence NDC pledges. Second, 2010 is a pivotal year in global climate governance, as the role of developing countries in climate action became apparent and mechanisms were set in place for these countries to propose and report on such action from this point on (e.g. through Nationally Appropriate Mitigation Actions, National Adaptation Plans and the Green Climate Fund). Third, 2010 rests centrally within the range of years that developed and developing countries define their relative target to, other than 1990 that is predominantly adopted by ex-Annex-I countries (i.e. 2005-2014). Finally, while we standardize targets relative to 2010 to observe GHGe trends relative to this year, we visualize these GHGe targets relative to historical emissions up to 2014 and relative to rates of change in GHGe a few years before Paris. We determine historical GHGe/cap by applying an annual technological discount rate of 2% between 1850 and 2010 (i.e. following the approach of den Elzen et al., 2013).

When NDCs provided estimates of 2010 GHGe levels (44% of initial NDCs' targets) and of business-as usual (BAU) projections to 2030 (93% of BAU-based targets), we used the NDC values to best represent countries' envisioned GHGe reductions. When NDCs did not provide such information, we relied on documentation submitted to UNFCCC, such as national communications or biennial reports through the UNEP Pledge Pipeline data[12]. Finally, when country-submitted data was unavailable, we used the Climate Action Tracker data[13], 2010 GHGe data from PriMap[14] (10% of targets), and projections data from the Climate and Energy College NDC & INDC

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12 Fenhann, J. 2019. Pledges Pipeline. UNEP DTU Partnership. https://www.unenvironment.org/explore-topics/climate-change/what-we-do/mitigation/pledge-pipeline

13 Climate Action Tracker. https://climateactiontracker.org/

14 Despite limitations, we used the older version of the PriMap database (2016) for historical GHGe data, as approximately two thirds of the analysed countries define their targets with a coverage of emissions that include LULUCF sectors (see Table 1) and the new database (2019) does not cover these sectors. From this database, we used GHGe defined based on the Fourth IPCC Assessment Report (AR4). The database can be accessed at: http://dataservices.gfz-potsdam.de/pik/showshort.php?id=escidoc:3842934

factsheets[15] (5% of BAU-based targets). We aimed to limit reliance on the latter three databases in order to ensure that our GHGe-reductions estimates were in line with countries' assumptions, setting this study apart from previous similar endeavours (King & Van Den Bergh, 2019; Meinshausen & Alexander, 2016; Robiou du Pont et al., 2016). Where GHGe targets only covered a share of the total GHG types and sectors, we assumed fixed GHGe levels between 2010 and 2030 for the omitted GHGe, based on the PriMap database.

We found that out of 155 initial NDCs submitted by the end of 2019 (including the European Union (EU) of 28 Member States as one), 123 had quantifiable GHGe targets and 110 had quantifiable targets to 2030. For the purpose of this study, we were able to standardize the GHGe targets of 100 of these initial NDCs[16] and an additional 9 'Intended Nationally Determined Contributions' (INDCs) of the 13 countries that had not yet submitted an NDC by the end of 2019 (i.e. Angola, Iran, Kyrgyzstan, Lebanon, Philippines, Russian Federation, Senegal, Turkey and Yemen).

In 2020, 42 updated NDCs were submitted, including one for the EU27 (this time excluding the United Kingdom, who submitted a separate NDC) as a whole. Of all 2020 updated NDC submissions, 37 contained quantifiable targets and were included in this study.[17] These new submissions covered initial NDCs by the Russian Federation and Senegal. We compared those to the INDCs out of lack of an early NDC. Aside from the aforementioned updated NDC submissions, Angola, Lebanon and Kyrgyzstan submitted their INDCs as initial NDCs. Iran, Philippines, Turkey and Yemen have not yet made official submissions of their NDCs and we are, therefore, using the INDCs as proxies.

The analysed targets were presented in different formats in the NDCs. Of the 109 first NDCs analysed, 79 had targets that were conditional on international support, and 77 had unconditional targets, with 47 NDCs covering both target types. While

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15 NDC & INDC factsheets. Australian-German Climate and Energy College. http://www.climate-energy-college.net/indc-factsheets AR4 data: http://climatecollege.unimelb.edu.au/ndc-indc-factsheets

16 Ten quantifiable NDCs were excluded for the following reasons: 1) Mozambique and Benin – target in the form of cumulative emissions; 2) Malaysia, Tunisia and Uzbekistan – target in the form of GHGe intensity per GDP and unavailable GDP projections; 3) Solomon Islands – unclear if unconditional contribution is a reduction compared to 2015 or to a Business-as-Usual scenario (BAU) and if the forestry sector is covered; 4) Sri Lanka – GHGe reductions provided per sector; 5) Seychelles – mismatch between indicated 2030 GHGe levels and pledged percentage reductions; 6) Sao Tome and Principe – substantial mismatch in GHGe data between NDC and PriMap database for 2005 and no available data for 2010 in the NDC; and 7) Trinidad and Tobago – substantial mismatch in GHGe data between NDC and PriMap (see Footnote 15) for 2013 and 2010, respectively.

17 See NDC Registry: https://www4.unfccc.int/sites/ndcstaging/Pages/Home.aspx for a full list. The NDCs whose targets could not be assessed in this study are those of Papua New Guinea, Nicaragua, Panama, Cuba and Suriname.

the updated NDCs tend to present the same target types, some differ: United Kingdom pledged its first unconditional target outside the EU; Rwanda pledged its first conditional and unconditional targets; Brunei, Kenya and Ethiopia pledged their first unconditional targets; Cambodia pledged its first conditional target; Colombia eliminated its unconditional target and increased the conditional target instead; Chile eliminated its conditional target. Table 3.1 shows the types of targets defined in the first and updated analysed NDCs. 70 GHGe-reduction targets in this study were originally defined relative to a BAU scenario and the rest were defined relative to a base year or as GHGe levels in 2030. In the updated NDCs, Singapore and Chile, changed their target type from GHGe intensity reductions to total GHGe levels for more transparency and comparability. The Dominican Republic now has a target defined relative to BAU rather than 2010. We excluded cumulative emissions reductions targets due to inability to calculate emissions levels in 2030.

Table 3.1 Covered types of GHG emissions, covered sectors and formulation of assessed countries' first and updated NDC GHG emissions reduction targets to 2030. LULUCF refers to the land use, land-use change and forestry sector.

Sectors and emissions covered (# countries)	Types of targets (# countries)
Kyoto GHGs from all sectors, including LULUCF (64, +8 under updated NDCs)	% reduction in target year (30 relative to a base year +1 under updated NDCs; 69 relative to BAU, + 1 under updated NDCs)
Kyoto GHGs from all sectors, excluding LULUCF (31, -3 under updated NDCs)	GHG emissions reduction in target year ($MtCO_2e$) (2 relative to BAU)
Kyoto GHGs from the energy sector (4)	Total GHG emissions in target year (5, + 4 under updated)
CO_2 emission from all sectors, including LULUCF (3)	% share reduction in GHG intensity (4 relative to a base year, - 2 under updated NDCs)
CO_2 emission from all sectors, excluding LULUCF (1)	
CO_2 emission from the energy sector (5, -1 under updated NDCs)	

Table 3.1 also indicates the coverage of sectors and GHGe in the analysed NDCs, grouped into broader categories. We found that just under two thirds of the analysed GHGe-reduction targets covered all Kyoto-defined GHGe sectors, including land use, land-use change and forestry (LULUCF) in the initial NDCs, but a few more countries expanded their coverage of sectors and GHG types in the updated NDCs. Targets additionally had several subtle GHGe coverage variations (e.g. excluding smaller sectors), which we captured in our analysis when GHGe data was available in the NDCs or other international reporting documents. Nevertheless, GHGe coverage may be slightly over- or under- estimated where this information was not readily available in primary sources. The economic sectors most frequently covered by GHGe targets in the assessed initial NDCs are energy, agriculture and waste, included by 73%, 60% and 60% of countries respectively. Moreover, only 32% of initial NDCs covered all

GHGs defined in the Kyoto Protocol: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. Most frequently covered types of GHGs were carbon dioxide (92%), methane (83%), and nitrous oxide (82%), and we assumed full coverage when these three were included. The other gases were each covered by around one third of countries. The GHGe-reduction targets of China and India only cover CO_2 emissions, leaving out a substantial global share of GHGe. Moreover, of all assessed NDCs, eight have not specified their covered GHG types and two have not specified their coverage of economic sectors, including large GHG emitters such as Saudi Arabia and Venezuela. We assumed full coverage for these countries.

Countries assessed in our study with initial and updated NDCs were responsible for 79% (68% with unconditional targets) of global GHGe, including LULUCF, in 2010. Nevertheless, the covered GHGe are lower, amounting to 30 $GtCO_2eq$ in 2010 for countries with unconditional targets and 34 $GtCO_2eq$ for all assessed countries, representing 62% and 70% (63% and 71%, including updated NDCs) of the global GHGe including LULUCF in 2010, respectively (global value based on PriMap data). Our results reflect the findings of a previous account of all official national GHGe targets, including for other years than 2030 and targets outside the Paris Agreement, that found a coverage of global GHGe of 76% (or 89% including USA[18]) in 2017 (see Chapter 2). Although not legally-binding, the high coverage of GHGe by targets under the Paris Agreement is a major achievement compared to the Kyoto Protocol where the share of global GHGe covered including LULUCF was a quarter at the start of the first commitment period (2008-2012, using PriMap data) and decreased to approximately one tenth in the second commitment period (2013-2020) following the drop out of several major countries (i.e. Japan, Russia and Canada, while the US never ratified the protocol).

3.3 Correlation analysis

Winkler et al. (2018) assessed how 163 countries explained the fairness of their contributions and found that a broad range of approaches are invoked in the NDCs, whereby 'small share of global emissions' and 'low emissions per capita' are the most prominent, invoked by 101 and by 60 countries respectively. The third and fourth most often invoked fairness principles refer to membership to the groups of Least Developed Countries or Small Island Developing States and to low GDP/

18 Our study excludes the United States of America as it had left the Paris Agreement at the time the study was carried out.

cap, highlighted by 55 and by 26 countries, respectively (ibid.). Out of these invoked fairness principles, the most frequent, 'share of global GHGe', does not comply with commonly accepted equity approaches. This principle does not account for the size of the population (i.e. GHGe/cap and respective responsibility), for relative GDP (i.e. GDP/cap and capability) nor for historical emissions (i.e. historical responsibility) (Höhne et al., 2014).

To enable comparison of GHGe-reduction targets within the country context, we visualize these targets relative to a set of indicators. First, we visualized GHGe-reduction targets relative to the three relevant fairness indicators most frequently invoke in countries' NDCs (Winkler et al., 2018; see above). Namely, we correlate targets to GHGe/cap, historical GHGe/cap (1850-2014) and GDP/cap, which also addresses Least Developed Countries and Small Island Developing States as countries of low GDP/cap. Secondly, we recognize that some countries' economies may be harder to decarbonize and analyse how standardized GHGe-reduction targets relate to emissions intensity (i.e. GHGe/GDP) and net fossil fuel exports as share of GDP. Thirdly, along the same line, we also assume that countries with recent GDP/cap growth that was strongly linked to high GHGe/cap growth are likely more reluctant to set high GHGe-reduction targets in the short term. To test this hypothesis, we plot countries' GHGe-reduction targets relative to GDP/cap and GHGe/cap growth rates over the period 2009-2014, to reflect the context prior to the Paris Agreement. Finally, to address conditional GHGe targets in the context of past international support, use as indicator the financial support received for climate change mitigation prior to and immediately following the Paris Agreement (2010-2017)[19].

As we encountered several instances of high yearly variations in GHGe data in PriMap, in particular when including LULUCF emissions, we excluded all 28 countries with yearly variations of more than 50% from the analysis of average GHGe/cap growth rates. Additionally, we constrained the average annual change in GHGe/cap to +/-10 tCO_2eq/cap over the given period.

In our analyses, we look for visual patterns of country groupings rather than running statistical correlation analyses. This approach intends to address the major differences between countries of different contexts and the multitude of factors that could influence GHGe-reduction targets, some of which were not included in this study, notably, political inclinations. We use the year 2010 for comparison to the relative

19 We used World Bank Indicators data for GDP and net fossil fuel exports (https://data.worldbank.org/indicator), OECD climate mitigation development finance data (recipient perspective) for financial assistance (http://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm) and UN DESA data for historic and projected population data (https://population.un.org/wpp/Download/Standard/Population/).

year of target standardization, as indicated above, and the year 2014 to represent countries' contexts just before the Paris Agreements, when most initial NDCs were drafted. All comparisons to GHGe level are run both for the fixed year 2010 and historically between 1850-2014.

We present the analyses using GHGe-reduction targets of initial NDCs and discuss the changes incurred by updated NDCs. All analyses figures presented in the manuscript are reproduced in the Supplementary Material for Chapter 3 to include updated NDCs. A focus on the initial NDCs allows for comparability, as not all countries have had a chance to update their NDCs. Moreover, it facilitates the assessment of the likely influence of recent international negotiations and country comparisons since the adoption of the Paris Agreement. In that sense, we address whether countries that had low GHGe-reduction targets relative to other countries in their group (i.e. similar (historical) GHGe/cap and GDP/cap) have increased their ambition in the updated NDCs.

In the next sections, we present our results and discuss their implications and their position relative to existing literature. First, we present detailed findings about countries' GHGe-reduction targets in the initial and the updated NDCs, including emissions coverage and target types. Second, we present and discuss the visual correlation analysis of all aforementioned indicators. Third, we further discuss the challenges posed by current NDC formats and existing data. Finally, we conclude with an overview of our results and recommendations for further transparency and improved comparability.

3.4 Results and discussion

3.4.1 Expected GHGe in 2030

Despite the high coverage of GHGe globally, NDCs are not sufficiently ambitious. According to the UNEP Gap Report (UNEP, 2019a), total GHGe including LULUCF must be reduced to approximately 25GtCO_2eq or to 41GtCO_2eq in 2030 to meet the 1.5°C or the 2°C targets of maximum mean global temperature increase. Global GHGe in 2010 were approximately 48GtCO_2eq (PriMap data). We find that GHGe covered by countries with unconditional targets are expected to increase by 29% by 2030 compared to 2010, while those of countries with unconditional and/or conditional targets (all countries in this study) increase by 38% (Table 3.2). Similar to our results, King & van den Bergh (King & Van Den Bergh, 2019) found an expected increase in total GHGe of 24% between 2015 and 2030 for their set of NDCs. With updated NDCs, covered GHGe are expected to increase 27% by 2030 relative to 2010 levels under unconditional targets and 34% under both conditional and unconditional targets. Total CO_2 emissions have so far increased by approximately 12% between 2010 and 2018 (Crippa et al., 2019; Olivier & Peters, 2019) and remain on the rise.

Over the next decades, developed countries with above-average GHGe/cap are required to reduce their emissions, while developing countries are offered the possibility to still increase their emissions or reduce more slowly to allow for economic development. By 2030, global GHGe/cap average would have to be 2.19tCO_2eq/cap for a maximum global temperature increase of 1.5°C or towards 2.98 tCO_2eq/cap for 2°C (UNEP, 2019, and applying UNSTAT Population data). We find that very few countries stay below either of these limits, and mostly only those countries that already had very low GHGe/cap (Figure 3.1). Exceptions are Norway, Dominican Republic, Switzerland, Morocco, Angola and Zambia, who all aim to reduce their GHGe/cap levels below the global average for a maximum temperature increase of 1.5°C, even though their emissions were higher in 2010. While GHGe/cap are further reduced through the updated NDCs, none of these countries plan to limit their emissions below or at the level of average GHGe/cap for a maximum 1.5°C global temperature increase. In the following, we analyse the GHGe-reduction targets of assessed countries in more detail in the context of country emissions, energy and economic indicators.

Table 3.2 GHG emissions in 2010 and expected emissions in 2030 of analysed countries. Global GHG emissions refers to the world-wide GHG emissions in 2010 based on PriMap database. Covered GHG emissions refer to emissions from the sectors and GHG types that are addressed by the assessed targets.

Type of target	Covered GHG emissions in 2010 (GtCO_2e; % total global GHG emissions)	Covered GHG emissions in 2030 (GtCO_2e; % 2010 covered GHG emissions)	GHG emissions in 2030 relative to 2010 (% 2010 total emissions of assessed countries)
Unconditional	30.0 GtCO_2e; 62% (63% including updated NDCs)	38.9 GtCO_2e; 129% (127% including updated NDCs)	+127% (125% including updated NDCs)
Unconditional plus Conditional	34.1 GtCO_2e; 70% (71% including updated NDCs)	47.0 GtCO_2e; 138% (134% including updated NDCs)	+134% (130% including updated NDCs)

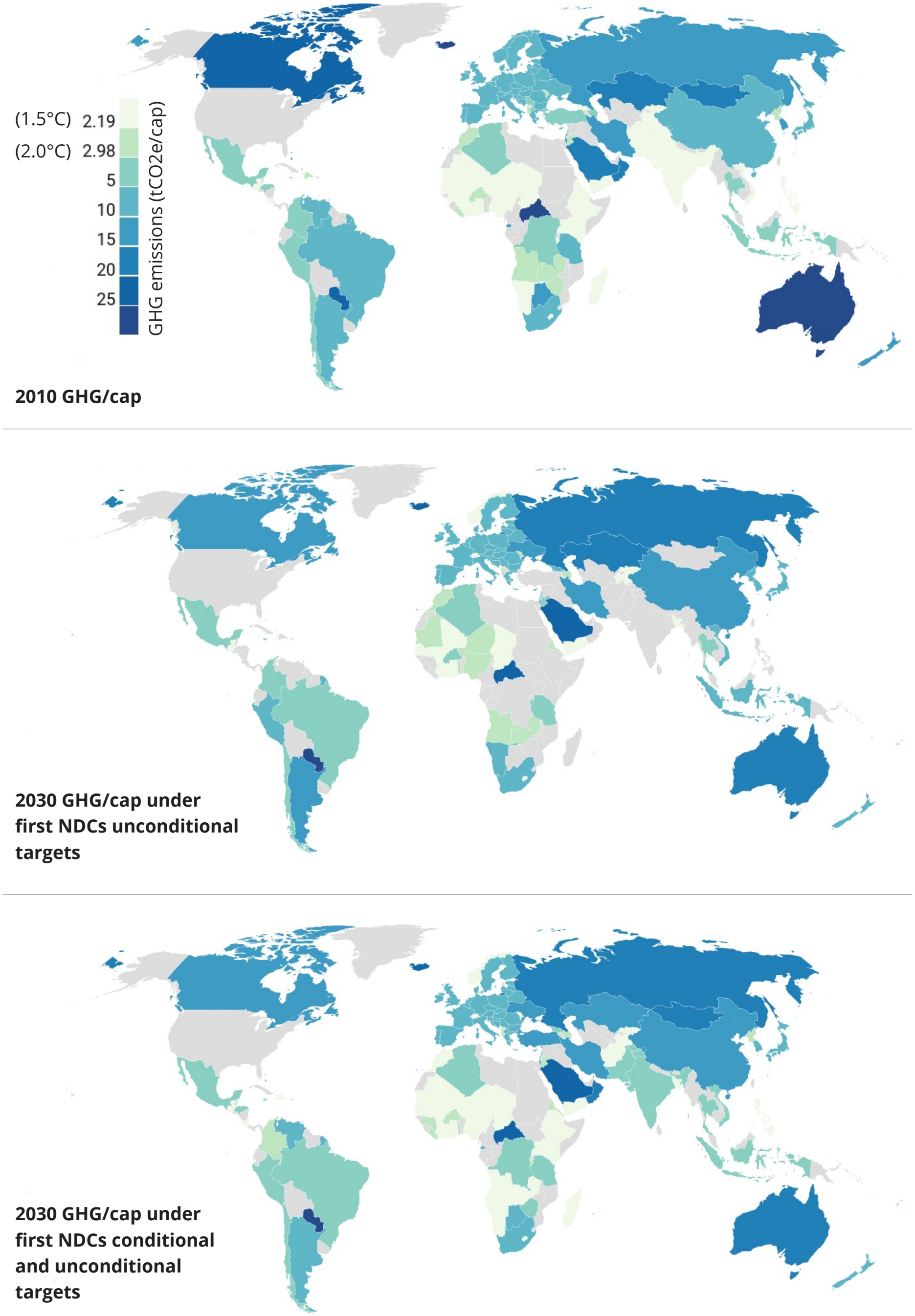
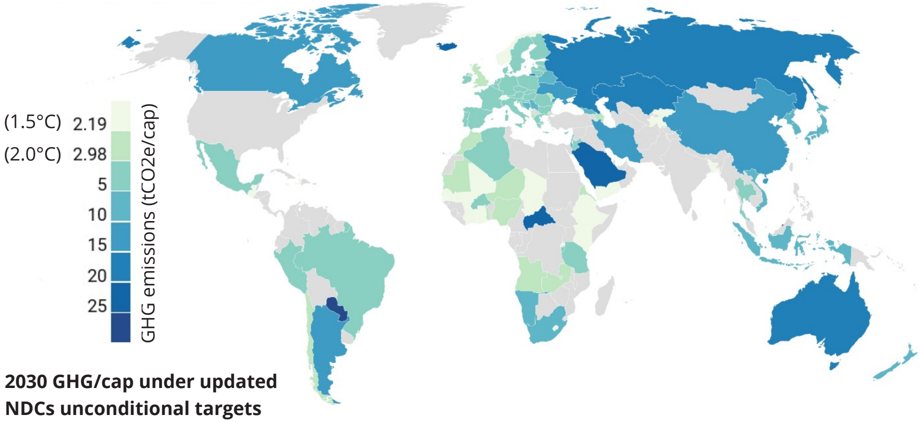


Figure 3.1 GHG emissions per capita in 2010 (based on PriMap) and 2030 (see Methodology), under unconditional and conditional NDC targets. The global average values for a maximum global temperature increase of 1.5°C and 2°C are based on the Emissions Gap Report (UNEP, 2019).



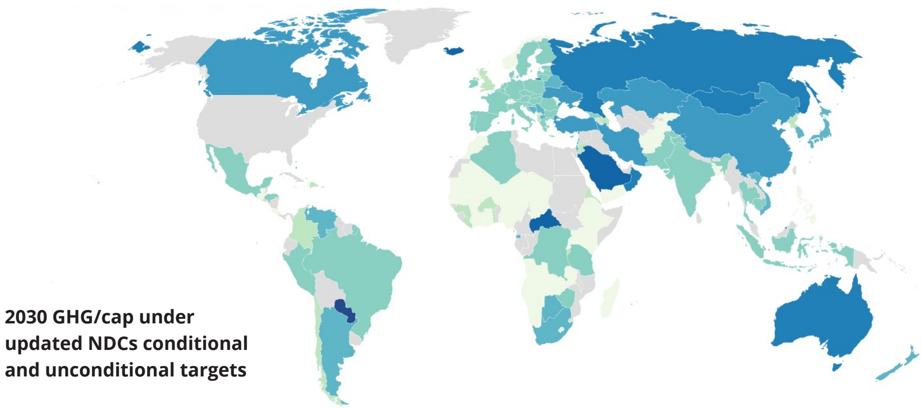


Figure 3.1 (Continued) GHG emissions per capita in 2010 (based on PriMap) and 2030 (see Methodology), under updated unconditional and conditional NDC targets. The global average values for a maximum global temperature increase of 1.5°C and 2°C are based on the Emissions Gap Report of 2019 (UNEP, 2019).

3.4.2 Comparison of GHGe reduction targets

As noted, (historical) GHGe/cap and GDP/cap are two key indicators that reflect countries' capability and responsibility to take climate action (Höhne et al., 2014) and the fairness rationales most often invoked in the NDCs (Winkler et al., 2018). Additionally, GHGe intensity of the economy and availability of cost-effective mitigation options are likely important determinants of emissions reductions. Following these arguments, we hypothesize that countries would tend towards the following changes in GHGe (see quadrants in Figure 3.2, representing country groups):

a. **Country type 1 (C1)**: countries with high capability, here illustratively depicted as high GDP/cap, but lower responsibility, here illustratively depicted as current and historical GHGe/cap, may aim to further reduce GHGe;

b. **Country type 2 (C2)**: countries of low capabilities and low responsibility are likely to foresee an increase in GHGe/cap due to expected economic development. Nevertheless, some, especially those with lower GHGe/GDP (C2a), may leapfrog into low-carbon economies;

c. **Country type 3 (C3)**: countries with low capability and high responsibility could be expected to reduce their GHGe/cap emissions under the principle of convergence towards a common global GHGe/cap value, but will also likely continue to grow due to economic development. High emissions intensity (i.e. GHGe/GDP), would require a deep restructuring of the economic and energy systems, substantial capacity, and access to low-carbon technologies. While some likely have cost-effective opportunities for mitigation (e.g. through improved efficiency), others likely have high marginal costs;

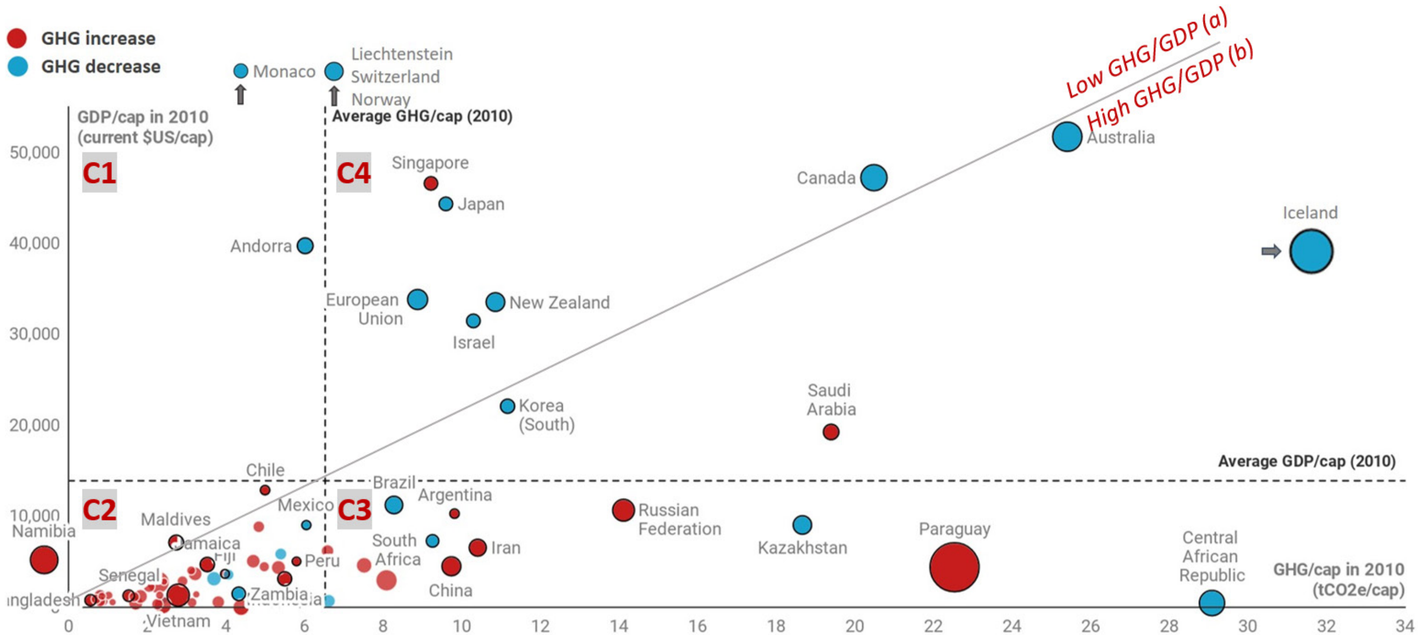
d. **Country type 4 (C4)**: countries of high capability and high responsibility are particularly expected to reduce their emissions. Nevertheless, high GHGe intensity (C4b) and economic dependence on fossil fuels would likely limit the willingness and ability for substantial reductions; and

e. Based on the dynamic of emissions intensity and cost-effective mitigation options, we expect that countries with recent downward trends of GHGe/cap and countries whose economic growth has been decoupled from GHGe are more likely to reduce their emissions regardless of the group that they belong to.

To test the above hypotheses, we first visualize countries' conditional and unconditional targets to 2030 against their GHGe/cap and GDP/cap values in 2010, when developing countries started reporting on mitigation action (see Figure 3.2). We also visualized these targets against historical GHGe/cap emissions up to 2014 and GDP/cap in 2014 to address historical responsibility and countries' contexts immediately prior to the Paris Agreement, respectively (see Supplementary Material for Chapter 3, Figure SM3.1). The results are similar to those in Figure 3.2.

Nevertheless, while Saudi Arabia falls under the group of countries with high GHGe/GDP, Singapore has low GHGe/GDP. Moreover, we find that countries with GDP/cap below average tend to increase their GHGe/cap emissions, but there are also some with negative trends to 2030, in line with our assumptions of low capabilities but also of willingness to leapfrog into low-carbon societies. Examples of low

a)


GHG increase
GHG decrease
GDP/cap in 2010
(current $US/cap)
50,000
40,000
30,000
20,000
10,000
C1
C2
C3
C4
Monaco
Liechtenstein
Switzerland
Norway
Average GHG/cap (2010)
Singapore
Japan
Canada
Australia
Low GHG/GDP (a)
High GHG/GDP (b)
Iceland
Andorra
European
Union
New Zealand
Israel
Korea
(South)
Saudi
Arabia
Average GDP/cap (2010)
Chile
Brazil
Argentina
Mexico
Maldives
Namibia
amaica
Fiji
Peru
South
Africa
Iran
China
Russian
Federation
Kazakhstan
Paraguay
Central
African
Republic
Senegal
Zambia
ngladesh
Vietnam
GHG/cap in 2010
(tCO2e/cap)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34

b)

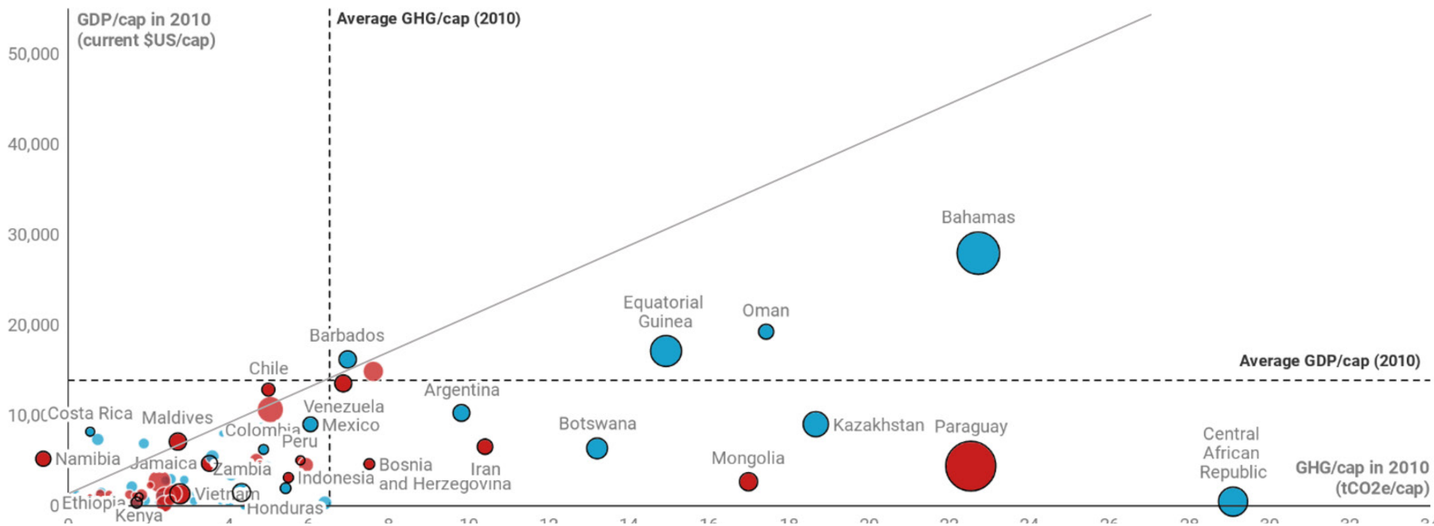


Figure 3.2 Countries' positions relative to GDP/cap and GHG/cap in 2010 and their respective a) unconditional and b) conditional (including unconditional share) first NDC GHGe targets. The size of the bubbles shows the increase (red) or decrease (blue) in total GHG emissions, including LULUCF, by 2030 compared to 2010 in tCO2e/cap. Scale of bubble size is not equivalent in the two figures. Countries indicated with arrow were positioned outside the scale. The average GDP/cap and GHG/cap (dotted lines) are defined as average across countries.

GDP/cap countries that already have low emissions intensity and continue to reduce GHGe/cap are Costa Rica, Fiji, Kiribati or the Marshall Islands, with the later three likely acting in response to their high vulnerability to climate change. Nevertheless, a few countries with low GDP/cap but high emissions intensity have also stated their interest to reduce their GHGe by 2030, for instance, the Central African Republic, Kazakhstan, Botswana and Zambia. Nonetheless, other countries with high current and historical GHGe/cap such as Russia and Paraguay continue to increase their emissions substantially to 2030. While Paraguay's high GHGe/cap emissions are primarily driven by the LULUCF sector, Russia's emissions are driven by the energy sector[20]. Nonetheless, both countries derive a considerable share of their GDP from exports of fossil fuels as we show in the next analysis (Figure 3.3b).

To further explore how countries' capability to reduce GHGe is reflected in their GHGe targets, we assess the influence of GDP/cap and of fossil fuels dependence (Figure 3.3b below and in Figure SM3.2 in the Supplementary Material of Chapter 3, whereby we present the same figure relative to 2010 GHGe/cap emissions). First, the trend of higher GHGe/cap reduction targets in countries with higher historical GHGe/cap is clearly visible, with the notable exception of Paraguay, where BAU is set very high. Second, here we more clearly observe that countries with higher historical GDP/cap tend to reduce their GHGe by 2030. The exception to this rule by highly fossil-fuel dependent countries like Singapore, Saudi Arabia and Russia is evident. Yet, we also see countries like Angola and Kazakhstan, with low GDP/cap and high fossil-fuel dependence, that aim to reduce their GHGe by 2030. Norway also aims to reduce its emissions, despite high dependence on fossil fuels and relatively low GHGe/cap emissions, but its higher GDP/cap implies higher capability. Clear outliers likely indicate laggards and role-models of climate action, but more in-depth analysis would be required to better understand the national contexts driving emissions in these countries.

Adding to the observation in Figure 3.1, Figure 3.3 also shows a clearly insufficient convergence towards the global average GHGe/cap necessary for a maximum global temperature increase of 1.5°C. Only nine analysed countries reduce their GHGe/cap by more than the required global average reduction. In general, countries with GHGe/cap above the required 2030 global average limit in 2010 should aim for higher reductions than the required global average reduction to offer low-emission developing countries the possibility of further development. Our results are in line with those of Watson et al. (Watson et al., 2019), where 75% of GHGe targets assessed were not meeting the requirements for a maximum global warming of 1.5°C.

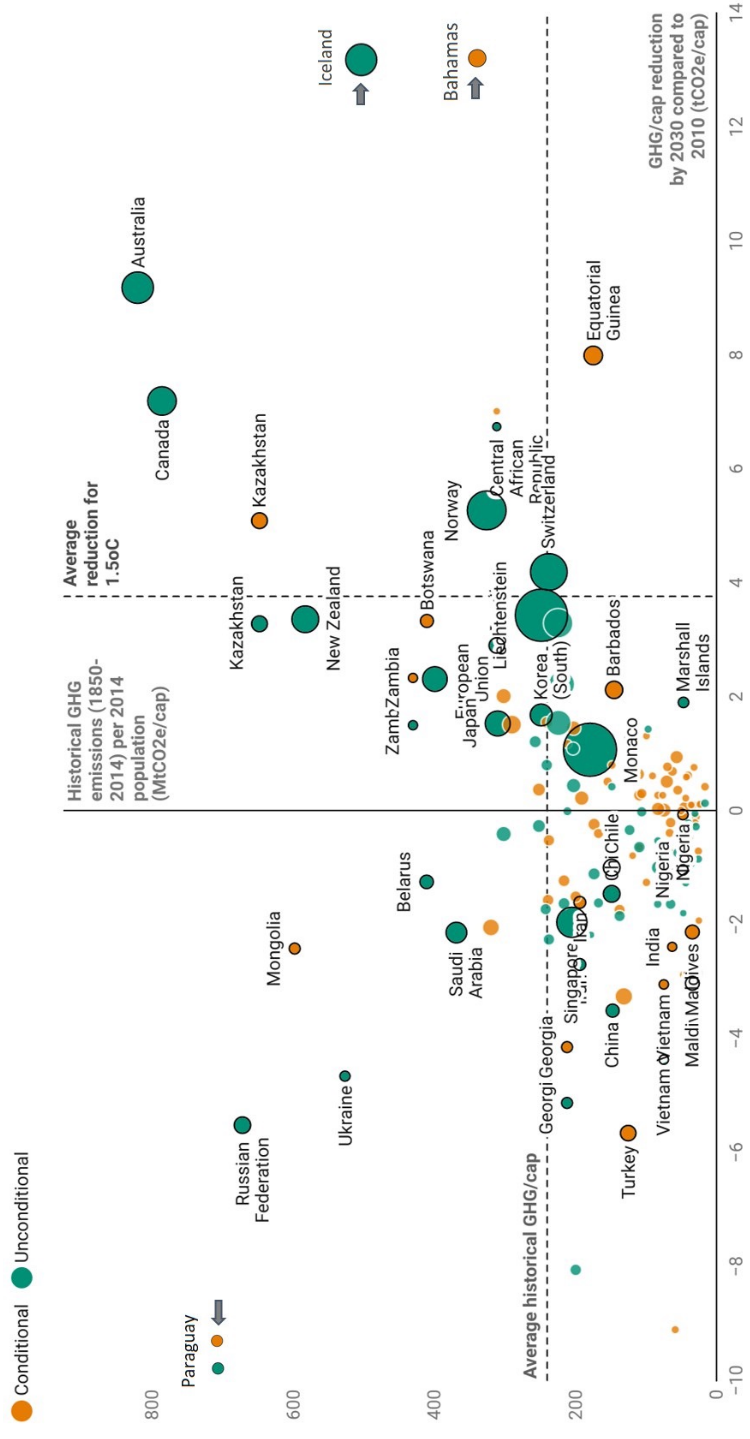
20 ClimateWatch country profiles of Paraguay: https://www.climatewatchdata.org/countries/PRY and Russia: https://www.climatewatchdata.org/countries/RUS

Recognizing the varied interrelations between GHGe and GDP across countries, we also analyse GHGe/cap reduction targets against recent trends in GHGe/cap and GDP/cap. We assess the hypothesis that countries with higher pre-Paris GHGe/cap growth (2009-2014), especially when coupled with GDP/cap growth, are generally more reluctant to set high targets than countries that were already on a downward trend of emissions or mostly decoupled from GDP growth. In that sense, we would expect Figure 3.4 to show primarily blue bubbles on the left side (i.e. negative GHGe/cap rate of change), especially where GDP/cap has grown, and red bubbles on the right side (i.e. positive GHGe/cap rate of change). We would also expect that countries with a high increase in GDP/cap and a decrease or low increase in GHGe/cap have economies that are not highly dependent on (and decoupled from) GHGe-intensive activities and would be willing to reduce GHGe more.

In contrast, we find no evidence of correlation between past rates of change in GDP/cap relative to GHGe/cap and pledged emissions reductions. However, some important observations can be made. Notably, countries that were identified in Figure 3.2 and Figure 3.3 to have low capability (GDP/cap) and responsibility (GHGe/cap) and yet aim to conditionally reduce GHGe/cap by 2030 (e.g. Costa Rica and Guatemala), are shown here to have had a significant decrease in emission and hence, to already be on a path that nurtures confidence in further reduction. On the other hand, Afghanistan and Kiribati had one of the highest growth rates in GHGe/cap and still aims to conditionally or unconditionally reduce their emissions by 2030. Importantly, most countries with targets that lead to an increase in GHGe/cap relative to 2010 despite an average decrease during 2009-2014 have defined their targets relative to high BAU scenarios and foresee GHGe changes that run contrary to historic trends. Most notably, Namibia projects 16 times higher GHGe by 2030 relative to 2010 under its unconditional target and close to 3 times under the conditional target, despite an average annual decrease of only 3% in GHGe/cap during 2009-2014.

Growth in GDP was historically correlated with GHGe increase, but reductions in energy intensity of GDP and in carbon intensity of energy have weakened this correlation over time (Peters et al., 2017). Countries are currently at different stages of the Kuznetz curve (Galeotti et al., 2006; Jalil & Mahmud, 2009) and a direct comparison of targets cannot be undertaken without due consideration of current development pathways. Factors such as technology transfer, capacity building and financial support for climate action, can help developing countries change the shape of their Kuznetz Curve and make a more rapid U-turn. In a later section, we assess how the provision of international financial support compares to countries' conditional GHGe targets.

a)


Conditional
Unconditional
Paraguay
Historical GHG emissions (1850-2014) per 2014 population (MtCO2e/cap)
GHG/cap reduction by 2030 compared to 2010 (tCO2e/cap)
Average historical GHG/cap
Average reduction for 1.5oC
Iceland
Bahamas
Australia
Canada
Equatorial Guinea
Kazakhstan
Central African Republic
Norway
Switzerland
Botswana
New Zealand
Liechtenstein
European Union
Japan
Korea (South)
Barbados
Marshall Islands
Zambia
Monaco
Belarus
Mongolia
Saudi Arabia
Chile
Nigeria
India
Singapore
Maldives
Georgia
China
Vietnam
Ukraine
Russian Federation
Turkey
0
200
400
600
800
−10
−8
−6
−4
−2
0
2
4
6
8
10
12
14

b)

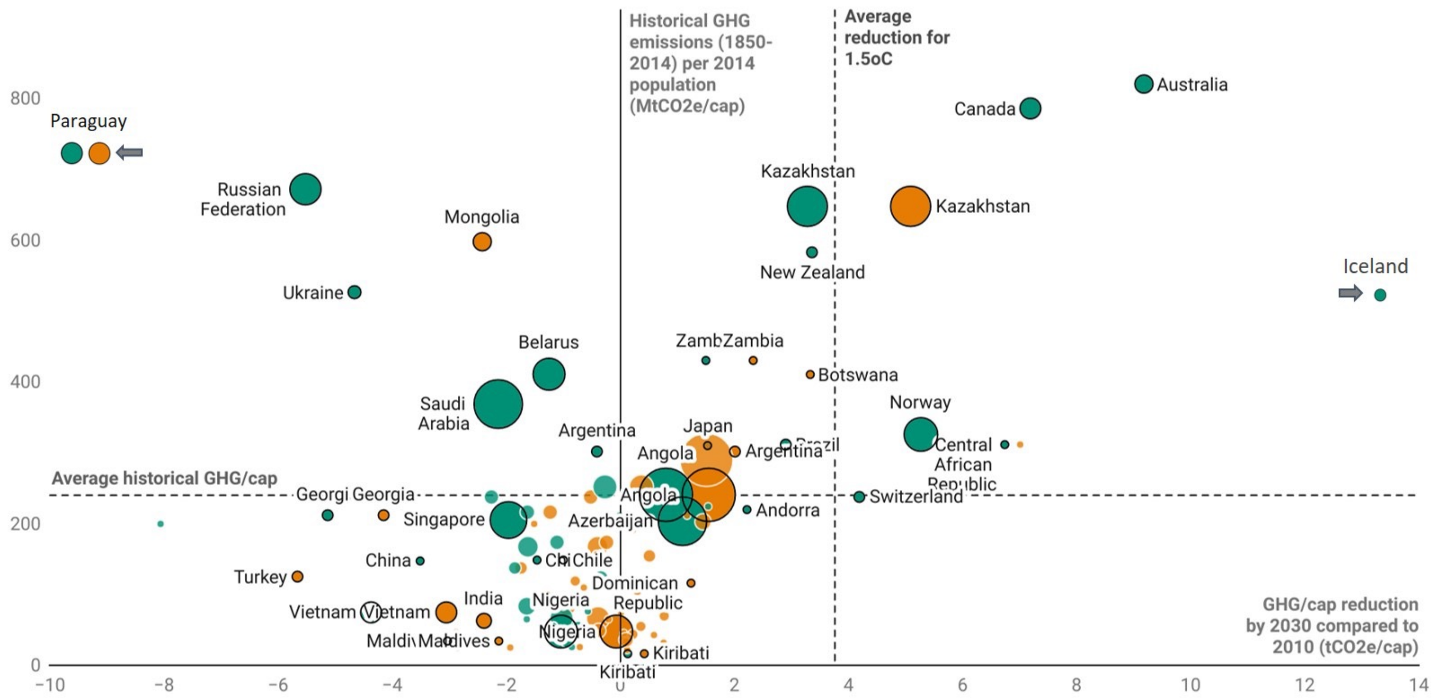


Figure 3.3 Countries' first NDCs GHG/cap unconditional (green) and conditional (including unconditional share, orange) reduction targets relative to their historical GHG/cap emissions (1850-2014). Size of the bubbles is given by a) GDP/cap in 2014, and b) average share of fuel exports per GDP between 2010-2017. The vertical dotted line labelled 'Average reduction for 1.5°C' indicates the global average reduction of GHG/cap needed by 2030 relative to 2010 to keep temperatures at a maximum increase of 1.5°C. Scale of bubble size is not equivalent across the two graphs. Countries indicated with arrow were positioned outside the scale.

a)


GHG increase
GHG decrease
Average GDP/cap growth (%, 2009-2014)
Average GHG/cap growth (%, 2009-2014) - total emissions
15
10
5
0
−5
−10
−8
−6
−4
−2
2
4
6
8
10
China
Russian Federation
Angola
Paraguay
Tajikistan
Colombia
Australia
Argentina
Yemen
Indonesia
Saudi Arabia
Korea
Singapore
Belarus
Namibia
Mexico
Algeria
Thailand
Guatemala
Burkina Faso
Maldives
Marshall Islands
South Africa
Norway
Kiribati
Monaco
Jordan
Albania
European Union
Morocco
Iran
Lebanon
Andorra
Japan
Central African Republic
San Marino

b)

Figure 3.4 Countries' average annual growth rate of GDP/cap and GHG/cap over the period 2009-2014. The size of the bubbles is given by the % share increase(red) or decrease(blue) in total GHG/cap in target year 2030 compared to 2010 under a) unconditional and b) conditional targets. Scale of bubble size is not equivalent across the two figures.

3.4.3 GHGe emissions reductions in updated NDCs

While the previous section focused on countries initial NDCs for comparability, in this section we further analyse all updated NDCs submitted by the end of 2020. In particular, we ask whether countries of comparably lower GHGe reduction pledges put forward more ambitious targets. We provide a reproduction of all figures in the previous analysis with the updated NDCs in the Supplementary Material for Chapter 3 for comparison.

We observe that, although updated NDCs were expected to be more ambitious, thirteen countries, most of which are developed, put forward the same levels of conditional and unconditional GHGe reductions as in their initial NDCs (Figure 3.5). Moreover, Costa Rica, Dominican Republic, DPR Korea, Senegal and Mongolia foresee higher GHGe in 2030 under the new target compared to the initial NDC target. In most cases, this is due to higher BAU under new applied methodologies.

Nonetheless, thirteen countries (including the EU as one) increase the ambition of their conditional and unconditional GHGe-reduction targets. Additionally, Ethiopia, Kenya, Brunei, Rwanda (and the United Kingdom outside EU) put forward their first unconditional targets and Colombia and Rwanda also have first conditional targets. Norway pledges further reductions, although it was already planning to reduce it GHGe/cap below the global average for a maximum 1.5°C temperature increase. Russia and Singapore, two countries that are increasing emissions despite high GDP/cap, pledge to further reduce GHGe/cap, although only marginally. Chile, also a country with above-average GDP/cap pledges new unconditional targets that reduces its 2030 GHGe/cap levels below 2010, unlike the initial NDC target; Jamaica does the same despite lower GDP/cap. Maldives and Peru also switch to reductions in their new conditional targets, despite being part of the low responsibility and low emissions group. However, the success of conditional targets is dependent on international support.

3.4.4 Conditional targets and international financial support

International finance is essential to boost climate action and conditional targets in developing countries and various mechanisms have been developed since the Kyoto Protocol. Although international climate finance has been limited to date, we hypothesize that recipients of larger amounts of climate mitigation assistance are likely to put forward higher conditional GHGe targets, due to experience, trust in international support and an increase in implementation capability. This hypothesis is tested in Figure 3.6, where we assess conditionally pledged GHGe reductions relative to

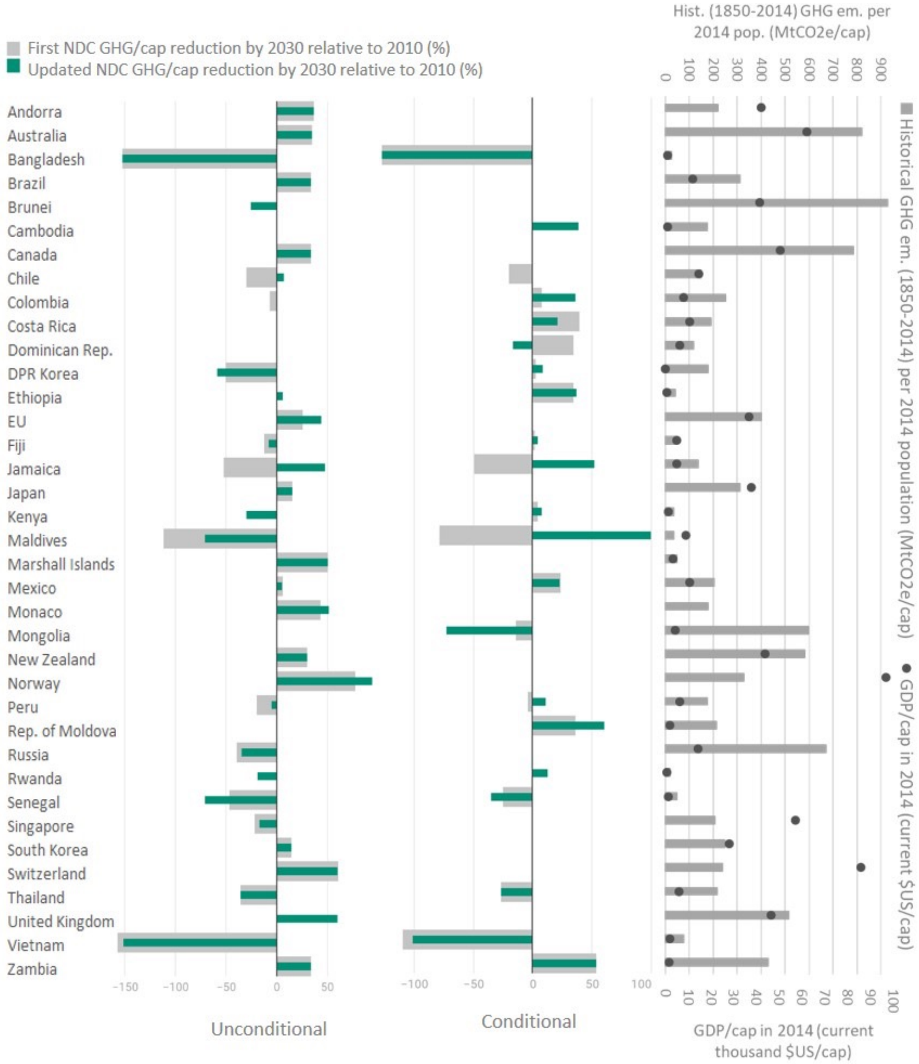


Figure 3.5 Comparison between first NDCs and updated NDCs GHG emissions reduction targets by 2030 relative to 2010 (tCO2eq). Negative values represent increase in GHG emissions. On the right, we present the key development indicators assessed in this manuscript (i.e. historical GHG/cap emissions (1850-2014) and GDP/cap in 2014).

average annual climate mitigation assistance[21] per capita received between 2010 and 2017 and to the country's GDP/cap in 2010. Additionally, we map the economic group countries were assigned to by the World Bank in 2020 to highlight how

21 We used data on development assistance reported by the Development Assistance Committee (DAC) members under the Organization of Economic Cooperation and Development (OECD) marked with climate mitigation as an objective. Accessed at: https://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm

some have developed during this period (e.g. Venezuela dropped from high income to upper-middle income), while Vietnam moved from low-income to lower-middle income.

We do not observe a clear correlation between international finance received and pledged conditional reductions, nor across different economic groups. While low-income countries appear to have received less financing per capita on average over the assessed period, their conditional reductions in tCO_{2eq}/cap are comparable to those of middle-income and high income countries. Moreover, as these countries tend to have lower GHGe/cap, the relative reductions (% of GHGe/cap) are higher than those of other economic groups, signalling high willingness for ambitious action, provided financial support. A reason for this result could be that countries of low capabilities (low GDP/cap) may seek to benefit from international climate finance to develop faster. By contrast, higher income countries have higher capabilities and will not receive assistance once they cross a certain income threshold, being less likely to expect substantial international financing. In some cases, observed high conditional targets may be the result of unrealistically high BAU as was previously indicated for Saint Kitts and Navis. Namibia is in a similar situation and with much higher projections, although it also has a high conditional target of 80% GHGe reduction relative to BAU. Turkey and Paraguay expect to triple their emissions in the given timespan. As with the other figures, the focus needs to be on trends rather than individual countries.

These results likely suggest that climate finance could be better targeted towards countries of greater need and willingness to reduce emissions in the future. While some argue that climate-mitigation finance should be delivered to countries that can reduce at the lowest cost (Bagchi et al., 2016), others have voiced the importance of local co-benefits, arguing in favour of least developed countries (Halimanjaya, 2015). Nevertheless, as Pauw et al. (Pauw et al., 2020) have shown, even the upper limit of pledged international finance ($100 billion per year, which countries are still far from reaching) is insufficient to meet demand, as 136 countries have made their NDCs conditional on international support.

3.5 Discussion and the way forward

This study revealed several limitations to compare GHGe targets and hence, to allow the peer-pressure process under the Paris Agreement to function appropriately. Here, we discuss those limitations and potential ways forward.

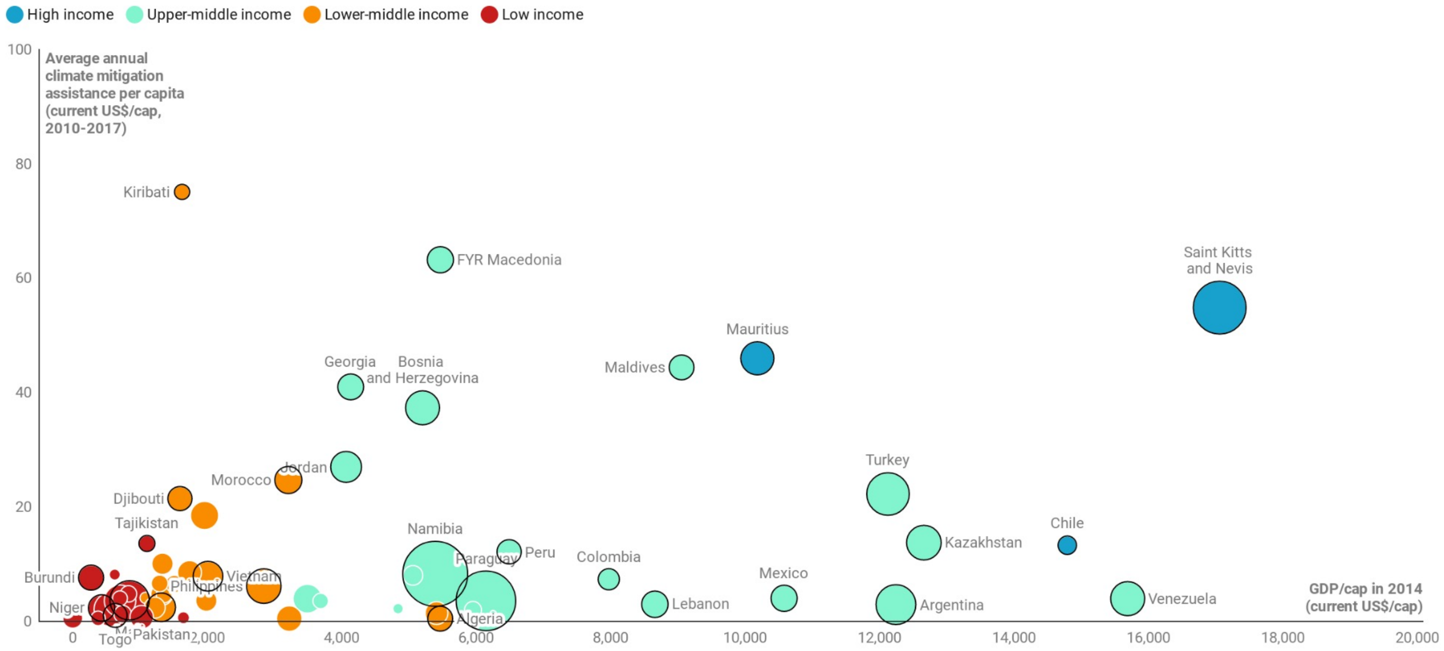


Figure 3.6 International development assistance for climate change mitigation (reported under OECD) over the period 2010-2017 and respective GDP per capita of countries in 2010. The size of the bubbles indicates pledged GHG/cap reductions by 2030 compared to 2010 under conditional targets (tCO2e/cap). The color of bubbles represents countries' economic groups in 2020 (World Bank categorization).

First, to facilitate comparison, we argue that stricter rules could require common target formats and a complete (or common) coverage of sectors and types of GHGe for all countries. In that regard, we find value in the use of absolute emissions reductions relative to a common year and the avoidance of BAU scenarios in target setting as the latter could add uncertainties and methodological differences. Similar to our results, King & van den Bergh (King & Van Den Bergh, 2019) found that targets defined relative to BAU tend to represent lower GHGe reductions, potentially suggesting overestimations of future emissions or psychological effects in target setting. Yet, current differentiation in treatment of development and developing countries under the Paris Agreement Article 4 and the Paris Rulebook[22] (Rajamani & Bodansky, 2019) likely encourage developing countries to use BAU scenarios and a limited coverage of sectors and emission types. Pauw et al. (Pauw et al., 2019) have found that all Annex-I countries with the exception of Turkey define their targets relative to a base year, while only 16% of emerging economies and 9% of Least Developed Countries do so.

Second, a lack of transparency on the coverage of GHG types and sectors, on assumed levels of GHGe in BAU and in the base year, and on expected levels of GDP in target year, make target comparison and standardization more challenging. Echoing the discourse in the literature, this paper also highlights the need to apply the principles of transparency, accuracy, consistency, comparability and completeness required for GHGe reporting under the 'enhanced transparency framework' also to target definitions (Falkner, 2016; Romain Weikmans et al., 2020). If NDC pledges do not reflect these principles, countries cannot unambiguously report on NDC implementation progress and comparison of targets becomes difficult. The Paris Rulebook addresses this issue through reporting requirements[23], but these depend on the type of target and developing countries have full freedom on how to define their NDCs (Rajamani & Bodansky, 2019).

Third, we suggest that future research could develop more complex, compound indicators, building on past approaches (e.g. Höhne et al., 2014). For instance, Kartha et al. (2018) highlight that equity approaches should also consider consumption- versus production-based emissions, survival versus luxury emissions, progressive versus regressive allocation of mitigation costs, prioritarianism versus egalitarianism, and various rights, such as the right to development and the right to poverty

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22 See full set of decisions in the 'Katowice Climate Package' (UNFCCC) (i.e. 'Paris Rulebook'): https://unfccc.int/process-and-meetings/the-paris-agreement/paris-agreement-work-programme/katowice-climate-package

23 FCCC/PA/CMA/2018/3/Add.1, Dec. 4/CMA.1, para 7, https://unfccc.int/sites/default/files/resource/cma2018_3_add1_advance.pdf#page=3

eradication. We additionally analysed GHGe target correlations with governance indicators[24] and with countries' vulnerability to climate change[25]. Yet, no strong correlations were found with these indicators individually, only a weak correlation with ND-GAIN, which aggregates indicators related to countries' vulnerability and readiness and was found to be correlated with countries' economic status, hence, with GDP/cap (Chen et al., 2015). GHGe-reduction targets act as guidance and their implementation depends on adoption of adequate measures. Future research could go beyond targets to measure progress on concrete policies and measures (Averchenkova et al., 2017; Nascimiento et al., 2021).

Finally, given a lack of clear rules for climate finance accounting, the literature presents a variety of figures and reporting under the UNFCCC also has shortcomings and lacks comparability across countries (Roberts et al., 2021; Romain Weikmans & Roberts, 2019). Moreover, the Paris Rulebook has failed to set clear methodologies to account for different financial instruments or for additionality[26]. The OECD Rio Markers, established for the Development Assistance Committee (DAC) reporting, have descriptive and qualitative purposes. Yet, the Markers have been used extensively by most developed countries and the OECD Database used in this paper remains the most relevant for climate finance flows (Romain Weikmans & Roberts, 2019). Nevertheless, improved methodologies for climate finance reporting are needed.

3.6 Conclusions

In this paper, we assessed how responsibility- and capability-related development indicators correlate with countries' GHGe-reduction targets in the NDCs, grouping countries based on their specific contexts. We found that GHGe-reduction targets are correlated with GHGe/cap and GDP/cap levels and growth rates. Yet, we cannot say that the amount of past international climate financial support received is a clear driver of ambitious conditional GHG targets. Moreover, while dependency on fossil fuel exports likely poses difficulties to GHGe reductions in some countries, it is not a definite blocker of ambition. Accounting for multiple perspectives to capture the

24 World Bank Worldwide Governance Indicators: https://info.worldbank.org/governance/wgi/

25 ND-GAIN Index (https://gain.nd.edu/our-work/country-index/) and Global Climate Risk Index (https://germanwatch.org/en/cri)

26 FCCC/PA/CMA/2018/3/Add.2, Dec. 18/CMA.1, Annex V.C. https://unfccc.int/sites/default/files/resource/cma2018_3_add2_new_advance.pdf#page=3

diversity of country contexts is important, and starting from a reduced set of key indicators can already provide valuable insights and identify leading countries.

We also found that many updated NDCs remain at the same level or even increase their planned GHGe in 2030. Initial NDC pledges fell well below the ambition needed to meet the Paris Agreement goal of keeping temperature increase well below 2°C. Hence, countries were expected to raise ambition in a new round of NDCs but the results show a mixed picture.

We argue that like with like comparison of GHGe-reduction targets enables the processes of peer pressure and soft reciprocity as countries become aware of their position relative to other countries with similar contexts. Such comparison allows to identify leaders in climate action and to facilitate mutual learning and a quicker diffusion of policy and technological innovations. Targets comparison is valuable not only to individual countries and UNFCCC negotiations, but also to relevant stakeholders such as researchers, businesses who wish to understand global trends and potential domestic impacts, and the civil society who could use this information to advocate for higher ambitions.

Yet, current diversity of ways to express the NDCs and available data limit such comparison. Hence, we emphasize the need for universal and stricter guidelines of NDC targets formats to allow for better accounting of GHGe reductions. In particular, defining targets of all countries as GHGe reductions relative to a common base year would eliminate differences in GDP or GHGe projections methodologies across countries. Coverage of all GHG types and sectors would enable accurate accounting of expected changes in emissions in individual countries and globally, through aggregation. A common target year would further allow the inclusion of more countries in the comparison. International climate negotiations are ongoing on the Common Time Frame and the Enhanced Transparency Framework and these could be used to better standardize NDC pledges. The ability to adequately measure targets and respective progress is essential for a successful global stocktake and for boosting climate ambitions.

Deserts are expanding as a result of climate change.
Photo taken at Dubai Desert Conservation Reserve, United Arab Emirates, 2019.

Climate change and related droughts threaten the water balance of highland lakes. Photo taken in Laguna Verde, Chile, 2014.

4

Aligning climate and sustainable development finance through a SDG lens

The role of development assistance in implementing the Paris Agreement

This chapter is based on:

Iacobuta, G., Brandi, C., Dzebo, A., Elizalde Duron, S. D. *Aligning climate and sustainable development finance through an SDG lens. The role of development assistance in implementing the Paris Agreement.* (Under peer review)

Abstract

Climate change and development are strongly interconnected. An efficient use of financial resources would, thus require alignment between climate finance and development priorities, as set out in the context of both the Paris Agreement and the 2030 Agenda for Sustainable Development. In this paper, we investigate to what extent climate-related official development assistance (ODA) before and after the Paris Agreement adoption supports the implementation of the Sustainable Development Goals (SDGs). Moreover, we assess to what extent donors align this finance with recipient countries' climate-related priorities as spelled out in their Nationally Determined Contributions (NDCs). First, we find that climate-relevant ODA contributes to multiple SDGs, above all SDG 7 (energy) and SDG 11 (cities). Second, we find that there is substantial alignment between donors' and recipients' SDG priorities, but that this alignment has not improved in recent years, since the conclusion of the Paris Agreement. Third, we find that albeit climate-finance continues to be allocated more to climate-change mitigation than to adaptation, the difference became smaller in recent years. This reduced the misalignment with recipient countries' NDC climate activities, which focus more on adaptation than on mitigation. Overall, we identify coherence, gaps and opportunities for further alignment of climate and development actions, and related finance. Such an alignment is essential to increase the likelihood of implementation of the two international agreements and to ensure that action is guided by recipient countries' needs.

4.1 Introduction

The Paris Climate Agreement and the 2030 Agenda on Sustainable Development, encompassing the 17 Sustainable Development Goals (SDGs), were both adopted in 2015. The purpose of these international agendas is to transition the world to low-carbon and climate-resilient sustainable development pathways. To date, however, countries are still struggling to take the necessary action and to set themselves on course to achieve these agreements. First, progress on SDG implementation has so far been slow (UN, 2019b). Second, pledges in Nationally Determined Contributions (NDCs) of Parties are still far from the Paris Agreement goal of limiting global temperature increase to well below 2°C and striving for 1.5°C (Climate Action Tracker, 2021; Höhne et al., 2020; Rogelj et al., 2016). Additionally, current national climate policies are insufficient to implement existing NDC pledges (for high greenhouse-gas emitters, see Roelfsema et al., 2020).

One major reason for the slow implementation of the Paris Agreement and the 2030 Agenda is the insufficient scaling-up and delivery of urgently needed climate and development finance (UN, 2020; UNFCCC SCF, 2018). On the international stage, countries agreed to mobilize US$ 100 billion annually by 2025. However, this amount is insufficient to meet developing countries' needs (Pauw et al., 2020). In parallel, achieving the 2030 Agenda for Sustainable Development worldwide requires an estimated US$ 5-7 trillion annually (UNCTAD, 2014). Yet, the SDGs remain underfunded (UN, 2019a). Moreover, the COVID-19 crisis caused a slide back in SDGs achievements and substantially limited available finance (UN, 2021).

Another major reason for the slow implementation is that the Paris Agreement and the 2030 Agenda have been addressed separately with limited consideration of their interlinkages. Achieving the targets set out in the two agendas will require deep transformations across all economic sectors, with intricate synergies and trade-offs between the pertinent objectives (Roy et al., 2018; UNEP, 2016). Given these interactions, the two international agendas would be best considered jointly in their implementation (Gomez-Echeverri, 2018; Janetschek et al., 2020, and Chapter 5 of this thesis). However, the current siloed approach led to progress on some SDGs at the detriment of others (IGS, 2019; Pradhan et al., 2017a). For instance, as the latest report on the SDGs progress shows, investments in fossil fuels as a result of development choices, continue to be higher than investments in climate activities (UN, 2020).

In light of limited financial resources and the interlinkages between the two international agendas, one essential question is how to make good use of existing financial support. Given the strong interlinkages between climate and development actions, increasing the effectiveness of climate and sustainable development finance would require coherence (i.e. minimizing trade-offs and maximizing synergies) between the two strands of finance (OECD, 2019). Moreover, increasing financial effectiveness and ownership of climate and sustainable development actions requires alignment of donor countries' finance with recipient countries' priorities, including their focus on mitigation versus adaptation (e.g. Bouyé et al., 2018; UNFCCC, 2017).

In our study, we explore the synergies between the Paris Agreement and the 2030 Agenda by investigating how climate finance contributes to the SDGs, and how these contributions align with recipient countries' stated climate and SDG priorities. We address three key questions. First, we assess what SDGs donors' climate-related finance has contributed the most to in the period 2010-2018. Second, we investigate to what extent this is aligned to recipients' SDG (targets) priorities, as expressed through their SDG-related NDCs activities. Third, we ask whether donor-recipient priorities are aligned concerning support for climate-change mitigation versus adaptation. When answering these questions, we additionally explore changes in the assessed indicators during the periods before and after the adoption of the Paris Agreement (2010-2015 and 2016-2018, respectively).

To do so, we assess the SDG-priority alignment of climate-related Official Development Assistance (ODA)[27] and recipient countries' pertinent NDC activities. Here, climate-related ODA refers to ODA that has climate change action as a 'principal' or 'significant' objective or that indicated a 'climate component', and thus addresses both climate and development objectives. The NDCs are national climate plans submitted by all countries under the Paris Agreement. As previous analyses showed, countries' pledged climate activities in the NDCs typically touch upon multiple SDGs (e.g. Dzebo et al., 2019). NDCs can therefore be categorised based on SDG priorities[28], the same as climate-relevant ODA.

The remainder of the paper is organized as follows: Section 2 further motivates our selection of alignment dimensions (i.e. SDGs and climate-change mitigation versus adaptation) for recipient and donor priorities; Section 3 presents the methodology and data used in this paper, including initial insights on climate-relevant finance distribution; Section 4 presents and interprets the results of the empirical analysis on NDCs and climate-relevant ODA priority alignment; and the final section concludes

27 This ODA is reported by the Development Assistance Committee (DAC) members under the Organization for Economic Co-operation and Development (OECD).

28 For instance, as conducted by the NDC-SDG Connections database (www.ndc-sdg.info), which is the database that we use in this study.

by highlighting key results and outlining policy avenues for better alignment of recipient and donor priorities in the context of climate and SDGs.

4.2 Motivation and background literature

Climate finance is a key ingredient for the implementation of the Paris Agreement as many developing countries made their NDC activities conditional on international support (Hedger & Nakhooda, 2015; Pauw et al., 2020; Zimm & Nakicenovic, 2020, and Chapter 3 of this thesis). Conditional climate action can contribute to strengthening the equity and ambition of countries climate action. Yet, it can also become the 'Achilles heel' of the NDC approach and undermine the goals of the Paris Agreement if financial demands are not met (Pauw et al., 2020). For instance, in Chapter 3 we found no correlation between the level of proposed conditional per capita greenhouse-gas emissions reductions in the NDCs and climate-relevant finance committed between 2010 and 2017. This emphasizes the importance of not only ensuring that climate finance is scaled-up globally, as agreed upon in the Paris Agreement, but also that this finance reflects countries' needs and sectoral priorities as expressed in the NDCs (UNEP, 2018).

While equity-based justifications for climate finance, such as solidarity or responsibility, can play an important role in the provision of financial resources (e.g. Rübbelke, 2011), donor interests are also relevant. For example, the aid-allocation literature (for a review, see Alesina & Dollar, 2000; Doucouliagos & Paldam, 2009) finds that donors are differently motivated to provide financial resources to recipients, including recipients' need or merit (e.g. in terms of a good policy environment, see Weiler et al., 2018) and donors' (economic or geopolitical) self-interests (e.g. Hoeffler & Outram, 2011). In climate finance specifically, three types of donor motivations are pertinent in terms of shaping allocation decisions (Pauw et al., 2020): supporting the provision of global public goods such as mitigation, which generate advantages both for donors and recipients (Rübbelke, 2011); using climate aid to obtain developing countries' backing in UNFCCC negotiations (Bagchi et al., 2017); and furthering their self-interest, for example, by supporting their export markets (Weiler et al., 2018), addressing negative spillovers (Bermeo, 2017), or financing the countries of interest to involved ministries (Peterson & Skovgaard, 2019). For these reasons, climate finance may not always match recipients' needs and priorities but follow donors' motivations instead.

Nonetheless, in the context of climate finance, exploiting synergies between contributions to climate protection and achieving the SDGs can generate incentives for both donors and recipients in view of a joint implementation of the Paris Agreement and the 2030 Agenda. The strong links between climate and the SDGs have been demonstrated (Hoegh-Guldberg et al., 2018; Huq et al., 2018; Roy et al., 2018; and Chapter 5 of this thesis) and most NDC activities include multiple SDG-relevant commitments (Brandi et al., 2017; Adis Dzebo et al., 2019; Janetschek et al., 2020). Hence, financing NDC implementation can simultaneously contribute to climate action and SDG implementation (Gomez-Echeverri, 2018). As a result, aligned implementation of climate and the SDGs can in turn motivate donors to supply needed resources to reap multiple benefits. This would make a more efficient use of financial resources and could be better justified to donors' constituencies, due to both development benefits and links to global public goods, including greenhouse-gas emissions reductions (Basak & van der Werf, 2019).

As the NDCs express recipient countries' priorities, allocating climate finance in line with these priorities, can increase the alignment between recipient interests and needs and donor finance decisions. This approach would promote policy coherence (OECD, 2019), as called for by the 2030 Agenda (SDG Target 17.14). Moreover, it would increase recipient countries' ownership, as stipulated by the Green Climate Fund (Kalinowski, 2020; Zamarioli et al., 2020) and therefore strengthen aid effectiveness (as highlighted by countries in the Paris Declaration on Aid Effectiveness in 2005, the Accra Agenda for Action in 2008, and the Busan Partnership for Effective Development Cooperation in 2011). Here we discuss two important dimensions of alignment between recipients' stated priorities and donors' choices.

The first dimension of alignment concerns the question whether climate-action priorities expressed in the NDCs are adequately taken into account by donors when allocating climate-relevant ODA. This dimension is essential as it does not only affect ownership, as indicated above, but it can also generate co-benefits by simultaneously promoting the implementation of the Paris Agreement and the 2030 Agenda as determined by recipients (Gomez-Echeverri, 2018). We expect that the allocation of climate-relevant ODA varies across different SDG-relevant issues. For example, data analyses showed that donors allocate more climate-relevant ODA to sectors with high mitigation potential, such as energy (SDG7), than to sectors with a lower potential, such as health (SDG3) or peace, justice and institutions (SDG16) (see 'Climate Change (total)' objective analysis on www.aid-atlas.org). However, these may differ from recipients' priorities. Misalignment on this dimension would likely forego opportunities to support recipient

The second dimension of alignment between recipients' and donors' priorities concerns the balance between support for climate change adaptation and mitigation. Climate finance is meant to address both types of climate action, adaptation and mitigation, in a balanced way (as outlined in the Copenhagen Climate Accord in 2009 and reiterated in the Paris Agreement in 2015), although it was never concretely clarified what such a balance would look like in practice. To date, climate-finance has been allocated more to climate-change mitigation than to adaptation (UNFCCC SCF, 2018). One key reason for a typically stronger focus on mitigation finance is that the former entails more benefits in terms of providing global public goods (Rübbelke, 2011) and more business opportunities, thus making it more attractive to the private sector (Agrawala et al., 2011). In contrast, finance for adaptation is often intertwined with development finance (Klein et al., 2005) and the opportunities for the private sector to invest and mobilize additional adaptation finance are much more challenging (Adis Dzebo & Pauw, 2019; Pauw, 2017). Yet, developing countries' NDC activities are likely to focus more on adaptation than on mitigation due to their vulnerability to the impacts of dangerous climate change (i.e. temperature increase beyond 2°C), and their lower (historical) GHG emissions and respective responsibility relative to developed countries. The UNEP Adaptation Gap Report (UNEP, 2021) indicates that the current annual costs of adaptation in developing countries alone are as high as US$ 70 billion and climate financial flows cover less than a half. Moreover, adaptation costs are expected to rise to US$ 140-300 billion in 2030 and US$ 280-500 in 2050 (ibid.). The ever stronger calls for scaled-up adaptation finance (de Nevers, 2015; Smith et al., 2011) and a better understanding of the private adaptation-finance potential (Goldstein et al., 2019) likely gave adaptation finance a boost in recent years. Hence, while we expect a mismatch between mitigation and adaptation finance relative to each other and relative to recipient priorities, we also expect to observe improvements in alignment over time.

By analysing these two dimensions, we aim to contribute to the debate on climate finance allocation and to elucidate how this finance contributes to sustainable development more broadly and vice versa. Investigating how climate-relevant ODA allocation compares to countries' NDCs can help identify key gaps and opportunities for further climate action through international assistance. Similarly, identifying sustainable development needs also helps and hints towards potential ways to make more effective use of international assistance for multiple development benefits and increased ownership. Our study provides tools that can analyse NDCs and climate finance data and likely support inquiries on improved alignment between donors and recipients' perspectives. In the following section, we will present our methodological approach of exploring the two selected dimensions of alignment.

4.3 Methodology and Data

We use the OECD external development finance data on committed climate-relevant ODA[29] to assess to which SDGs climate finance has contributed during the period 2010-2018. Here, we used finance data from recipients' perspective to enhance comparability with NDCs in view of disagreement between donors and recipients on reported ODA (Weikmans & Roberts, 2019). To ensure a high coverage of climate-relevant ODA, we included committed climate-relevant ODA from all types of donors (i.e. DAC and Non-DAC members, multilateral development banks, other multilaterals and private donors) through all types of financial instruments (i.e. debt instruments, debt relief, equity and shares in collective investment vehicles, grants and mezzanine finance instruments, unallocated/unspecified)[30] and with all pertinent objective types (i.e. principal, significant and climate component[31]).

Nevertheless, as we assess climate-relevant ODA data relative to countries' NDC activities, we only included finance committed to parties to the UNFCCC, where the assigned sectors could be directly linked to individual SDGs. Hence, we excluded financial transfers committed to broader regions, overseas or disputed territories (e.g. Kosovo, West Bank and Gaza Strip), and to Libya, as the only country that had not submitted an NDC. Overall, this excluded finance amounting to 16% of the total climate-relevant ODA over the period 2010-2018. Moreover, we eliminated transfers that did not indicate the (sub-)sectors, amounting to 2% of total climate-relevant, and those (sub-)sectors that could not be linked to the SDGs due to their broader or unspecific description, subtracting 7% more.

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29 OECD DAC External Development Finance Statistics - Climate Change. http://www.oecd.org/environment/climate-change.htm. While ODA data entails several weaknesses due to the self-reporting procedure which is likely to produce overestimations and labelling mistakes (Junghans & Harmeling, 2012; Michaelowa, A., & Michaelowa, 2011; Roberts et al., 2021; Weikmans et al., 2017; Weinlich et al., 2020), it remains the best data source available.

30 Of these instruments, only grants and debt relief (23% of analysed climate-relevant finance) would remain fully with the recipients, in particular when they are not tied to any conditions. Yet, as the interest rate and other details concerning the other instrument types often remain confidential, the amount of finance that the recipient country would fully benefit of is impossible to disentangle. However, while such a distinction is key in determining the total amount of international climate finance (Roberts et al. 2020) and the extent to which developed countries live up to their promises, it is less essential for the type of analyses undertaken in this study, which merely seeks to determine the focus areas of action.

31 The OECD database provides an indication to the role of climate as an objective to individual projects based on these three tiers, whereby 'climate component' is an approach used by multilateral development banks, in line with the 'significant' type of the OECD methodology. For parts of the analysis, we choose to also analyse climate finance that was committed to climate adaptation or mitigation as a 'principal' objective, rather than only as a 'significant' or 'component' contribution.

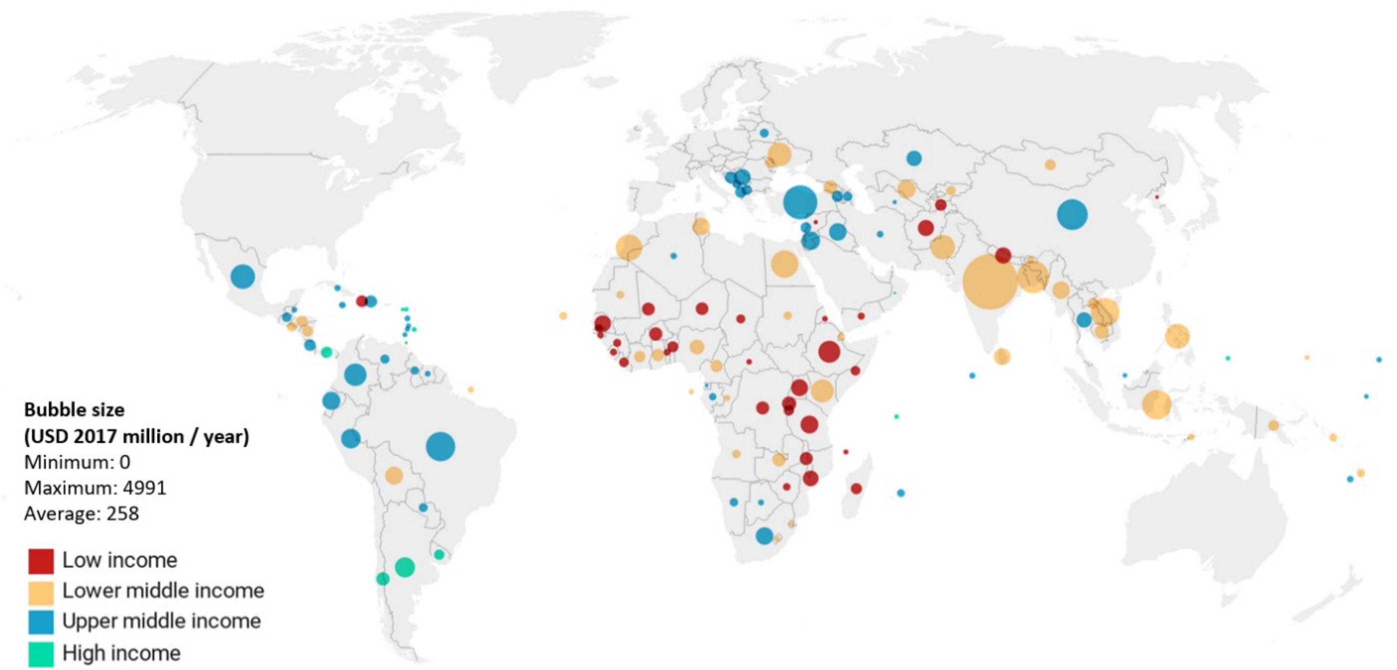

Figure 4.1 Average annual climate-relevant finance received between 2010-2018 (US$ 2017, million per year) by a recipient country, including all climate objective levels (principal, significant and climate component). This figure only shows climate-relevant finance included in this study, covering approximately 75% of the total climate-relevant finance.

The remaining financial data covered 146 recipient countries and approximately 75% of the total committed climate-relevant ODA between the period 2010-2018. Figure 4.1 presents the country-level distribution of committed climate-relevant finance that was included in this study. On average, according to OECD data, US$ 28 billion of climate-relevant ODA was committed annually in the pre-Paris period (i.e. before 2010-2015), excluding regional financing. In the post-Paris period (i.e. after 2016-2018), this annual average doubled to reach US$ 54 billion.

To analyse climate-relevant ODA data through a SDG lens, we allocated all (sub-) sectoral categories in the OECD climate database to specific SDGs and respective targets. For instance, the sub-sector ‘Employment creation’ (ODA code 16020) was attributed to SDG8 on economic growth and employment, and its respective targets 8.5 (on achieving full and productive employment) and 8.6 (on increased share of youth in employment, speaking to this ODA sub-sector’s consideration of ‘vulnerable groups’). In some cases, ODA (sub-)sectors could be attributed to more than one SDG. The sub-sector ‘Employment creation’, for example, could secondarily be allocated to SDG9 on industry and infrastructure, Target 9.2 (increase industry’s share of employment). In our study, we only used primary SDG target links, as these were most likely to reflect projects under a respective sectoral label and ensured limited double-counting. As the focus of the analysis was climate-labelled finance, we assumed the scope of the (sub-)sectoral categories in some cases (e.g. education activities include climate-related topics in curricula). We provide a comprehensive overview of our categorization in Excel format in the Supplementary Material of this chapter’s submission for publication, including both primary and secondary SDG target links.

For an overview of NDCs climate-activities’ links to the SDGs, we used the NDC-SDG Connections dataset. This dataset extracts future-oriented NDCs climate activities and categorizes them by SDG target. To ensure full comparison to the finance data, we only included the 146 climate-finance recipient countries, accounting for a total of 7455 NDC activities from the NDC-SDG Connections dataset.

To analyse the alignment of priority areas of climate-relevant ODA and NDC activities, we investigated the correlation between the shares of finance and of NDC activities dedicated to each SDG and their respective targets. To reduce mismatch due to different costs of climate activities, we conduct our analyses of climate-relevant ODA commitments both for financial flows (in US$ 2017) and for transactions (i.e. the number of data points recorded in the finance dataset). Moreover, we run the analysis both on a country-by-country basis and using global averages. While the country-by-country assessment can show direct alignment between recipients’ stated priorities and donors' allocation of funding, the global assessment can indicate general tendencies from the donor and recipient perspectives.

4.4 Empirical Results and Discussion

This section presents and interprets the results of the empirical analysis of alignment between NDCs and climate-relevant ODA. First, we present the results of our analysis using global averages across SDG categories. Here, we cover two aspects: alignment of priorities concerning SDG-level categories of finance and NDCs actions; alignment of mitigation- and adaptation-related finance and NDCs actions allocations, both overall and by SDG. Second, we present the alignment of priorities based on SDG target-level categories. And third, we present the results of our country-by-country assessment of direct finance and NDCs actions using SDG-level categories.

4.4.1 Global SDG-level analysis and allocations for climate adaptation and mitigation

In this section, we first analyse the links of climate-relevant ODA to the SDGs before moving into an alignment analysis between climate-relevant ODA and NDC activities. Hence, we first asked whether and how climate-relevant finance has contributed to the SDGs. Our analysis of donors' allocation of climate-related ODA through the SDG-lens shows that committed climate-relevant ODA contributes to all SDGs (see Figure 4.2[32]). At the same time, we find that the share of committed climate-relevant ODA and of respective transactions vary strongly across the SDGs. The largest share of committed climate-relevant ODA can be linked to SDG7 (energy) and SDG11 (cities), followed by SDG2 (zero hunger), SDG15 (life on land) and SDG6 (water) (see Figure 4.2, top). However, the highest share of transactions contributes mostly to SDG2 and SDG15, followed by SDG6 and SDG7 (see Figure 4.2, bottom). Finally, the largest share of NDC activities (same in Figure 4.2a&b) are attributable to SDG7, SDG2 and SDG15, followed by SDG6, SDG11 and SDG13 (climate change)[33]. While the

32 In brief, the SDGs address the following sectors: SDG1 (reduced poverty); SDG2 (zero hunger); SDG3 (health); SDG4 (education); SDG5 (gender equality); SDG6 (water and sanitation); SDG7 (energy); SDG8 (economic growth and jobs); SDG9 (industry and infrastructure); SDG10 (inequalities reduction); SDG11 (cities and human settlements); SDG12 (natural resources and sustainable consumption and production); SDG13 (climate-change action); SDG14 (life under water); SDG15 (life on land); SDG16 (peace and institutions); SDG17 (partnerships).

33 While this SDG directly addresses climate change, its individual targets are narrowly formulated. For this reason, although all NDC activities are meant to address climate change, not all of them were coded

data shows variations across climate finance, transactions and NDC activities, the six aforementioned SDGs are prominent across all three assessed variables.

The focus of both recipients and donors on SDG7 is unsurprising in light of the considerable mitigation potential of the energy sector, existing gaps in reaching needed energy efficiency and renewable energy targets (Roelfsema et al., 2020), and this sector's key relevance in supporting (sustainable) development. According to the IPCC (IPCC, 2018a), renewables are projected to supply approximately 70-85% of electricity globally by 2050 in scenarios of a maximum global temperature increase of 1.5°C without overshoot, while the share of renewables in electricity generation only covered 12.9%, excluding large hydro (Frankfurt School-UNEP Centre/BNEF, 2019). At the same time, more and more countries are seeing enormous increases in energy demand as a result of increased energy access and economic development, requiring improved energy efficiency and more renewable energy capacity. Similarly, the attention given to SDG11 (cities) reflects the rapid urbanization and the large share of greenhouse gas emissions by cities (71%–76% of energy-related CO_2 emissions in 2006 already (IPCC, 2014) along with the potential and need to strengthen sustainability across sectors and to reduce disaster risks (Gomez-Echeverri, 2018; IPCC, 2018b). Nevertheless, as mitigating greenhouse-gas emissions can become costly and hit technological and societal limits, countries will also need to look towards enhancing carbon sinks through forest- and ecosystem-based activities (IPCC, 2018a), represented by SDG15 and reflected both in the NDCs and in the climate-relevant finance allocation.

Additionally, as climate change begins to pose serious threats to food and water security (IPCC, 2019), both NDCs and climate-relevant finance pay, probably unsurprisingly, substantial attention to these areas (i.e. SDG2 and SDG6, respectively) that are tightly linked to key basic human needs. In general, higher shares of adaptation actions are observed under the more socially-oriented SDGs – SDG1 (poverty), SDG2, SDG3 (health), SDG4 (education), SDG5 (gender equality), SDG10 (inequality) and SDG16 (peace, justice and strong institutions) – and the environmentally-oriented SDGs (i.e. SDG6, SDG13, SDG14 (oceans) and SDG15), but not all of these SDGs are prominently addressed. While SDG13 and SDG17 (partnerships for the goals) are shown to have numerous activities in the NDCs, our analyses suggest that they are not strongly represented in the climate-relevant finance data. However, this cannot be seen as a lack of alignment but rather a reflection of the different perspectives

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under this SDG in the NDC-SDG Connections dataset. The SDG13 Targets are: 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries; 13.2 Integrate climate change measures into national policies, strategies and planning; 13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.

presented by the two datasets (NDCs representing the demand of recipients and ODA representing allocated donor support). Climate-relevant ODA could be linked to SDG17 in its totality, as it represents international cooperation and support. Similarly, all climate-relevant finance, especially when climate is a principal objective, could be linked to SDG13, but we chose to strictly reflect the more narrowly defined targets of this SDG (see Footnote 35), same as for the NDCs. Additionally, the ODA data was likely more explicit about the areas of activity for improved adaptive capacity and disaster risk reduction, and were therefore captured by other SDGs.

While we find that the focus of finance changed from the pre-Paris to the post-Paris periods, these changes are not very large, except for those related to SDG7 and SDG15. Electricity and heat has been the sector of highest greenhouse gas emissions globally (with variations across countries), requiring substantial climate mitigation efforts that were historically impeded by high costs. The decrease in the share of finance for SDG7 combined with a parallel slight increase in the share of transactions likely reflects the drop in costs of renewables and other low-carbon energy-related technologies. Over the past decade, specific renewable sources have become the cheapest option for new electricity generation in many countries, due to a decrease in the 'levelised' cost of electricity production of 81% for solar and 45% for onshore and offshore wind (Frankfurt School-UNEP Centre/BNEF, 2019). However, new policies around financing of solar power in China have led to a drop in total global financing for renewables in 2018 (ibid.). Yet, although all projected pathways to limit global temperature increase to 1.5°C without overshoot require substantial use of CO_2-emoval options (IPCC, 2018a), the share of both climate-relevant finance and of transactions related to SDG15 decreased relative to the pre-Paris period. Instead, the decrease in allocated finance to SDG7 and SDG15 has resulted in an increase in the share of allocated finance in other important areas such as SDG2 and SDG11, addressing the other key sectors of global greenhouse gas emissions – agriculture, transport, and buildings (IPCC, 2014).

Nonetheless, while industry has also been a key dominating sector of global greenhouse gas emissions, the share of dedicated climate-related ODA and transactions to SDG9 (industry and infrastructure) remained limited. When running this assessment only for finance where climate was the 'principal objective', we observe broadly similar results, with two notable exceptions: SDG7 was allocated higher shares of this finance (37%-40%) than of the total climate-related ODA and the value of this share was slightly higher in the post-Paris period (see Figure SM4.1 in the Supplementary Material for Chapter 4); moreover, the financial allocation for SDG11 has decreased substantially in the post-Paris period.

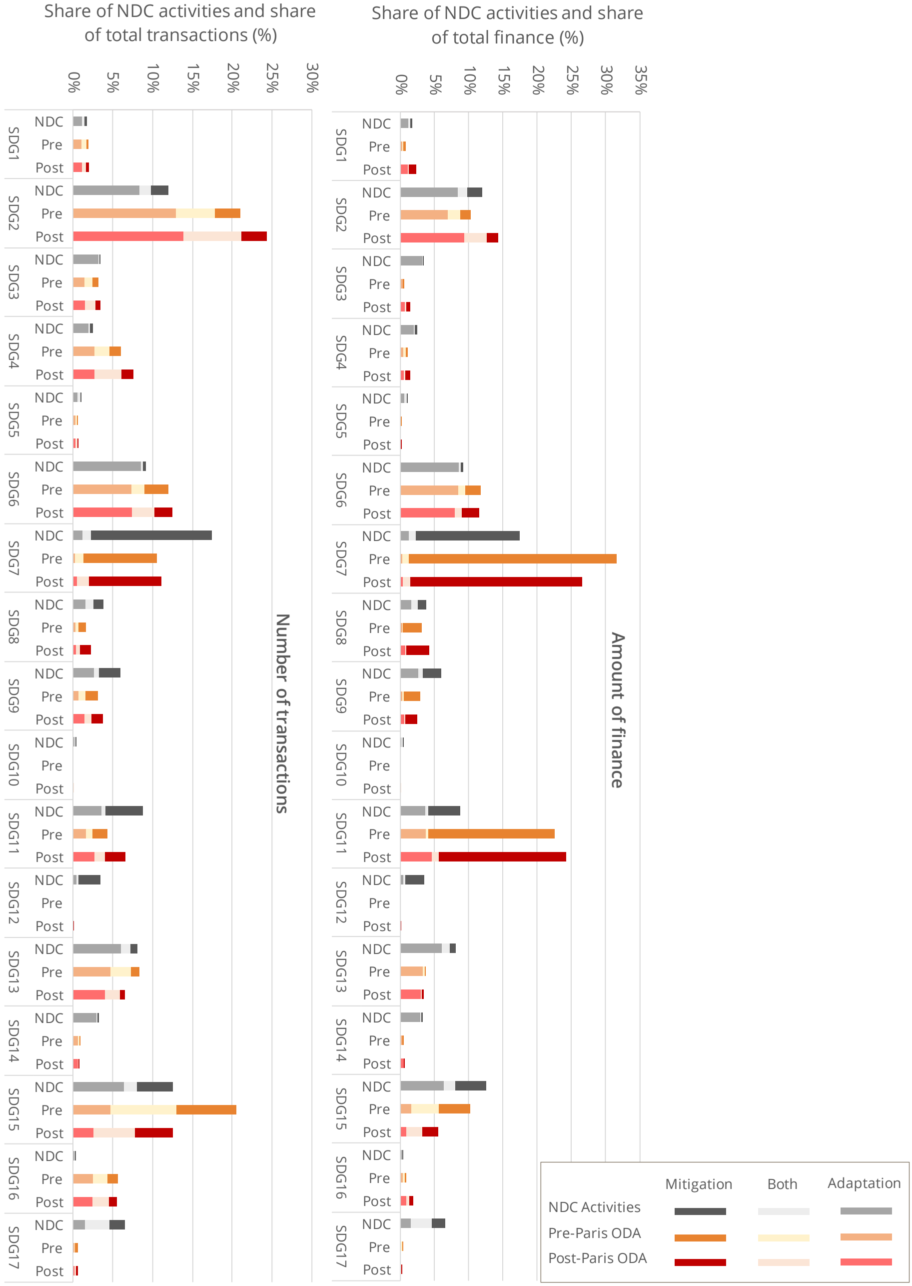

Figure 4.2 Share of NDC climate activities, and pre-Paris (2010-2015) and post-Paris (2016-2018) climate-relevant ODA and respective transactions by SDG, divided based on their main objective – climate change mitigation, adaptation or both. This figure presents financial data that covers all objective types (principal, significant and climate component, summed up). For a presentation of financial data with climate as the 'principal' objective, see Figure SM4.1 in the Supplementary material.

In a second step, we explored whether the overall climate-related ODA allocation across the SDGs is aligned with the share of NDC activities related to those SDGs, and whether this alignment has improved for post-Paris finance. To tackle the first dimension of alignment discussed above, we analyse the correlation between SDG-related allocation shares across finance, transactions and NDC activities that were presented in Figure 4.2. Furthermore, we address the second dimension of alignment by assessing the correlation of mitigation- and adaptation-related allocations across the SDGs and in total by donors and recipients (finance, transactions and NDC activities).

*Table 4.1 Correlation analysis between recipient countries NDC climate activities and climate-relevant finance and respective transactions. The analysis is conducted for all types of climate activities (adaptation, mitigation, both, total) and all objectives as well as principal objective only, across all 17 SDGs. Correlation coefficients, r(15), marked with * have p-value<0.001. All other values have p-value>0.1. The 15 degrees of freedom are given by the number of SDGs.*

Correlation Coefficient	Finance				Transactions			
	All objective types		Principal objective		All objective types		Principal objective	
	Pre-Paris	Post-Paris	Pre-Paris	Post-Paris	Pre-Paris	Post-Paris	Pre-Paris	Post-Paris
Adaptation	0.88*	0.83*	0.91*	0.87*	0.86*	0.81*	0.84*	0.87*
Mitigation	0.92*	0.87*	0.92*	0.96*	0.82*	0.90*	0.81*	0.89*
Both	0.38	0.32	0.32	0.36	0.32	0.22	0.36	0.31
Total	0.84*	0.78*	0.81*	0.87*	0.73*	0.71*	0.75*	0.82*

We find that the observed relative alignment between recipient SDG-related priorities and donor decisions (Figure 4.2) is substantiated by a correlation analysis, whereby the total allocations of climate activities and finance/transactions are strongly and positively linearly correlated (Table 4.1; and scattered graph with trend lines in Figure SM4.2 in the Supplementary Material of Chapter 4). However, a tendency towards stronger alignment between recipient and donor priorities after the conclusion of the Paris Agreement is not clear. While an increase in correlation for finance and transactions with climate as principal objective exists, a slight decrease in correlation for the overall climate-related ODA is observed (Table 4.1, 'Total'). Although this could suggest that climate-related ODA was better targeted (and marked as 'principal objective') in the post-Paris period in response to the NDC demands, similar trends are not observed when SDG-categorised finance is broken down by purpose (i.e. adaptation, mitigation or both). The alignment from pre-Paris to post-Paris for mitigation principal objective climate finance and respective

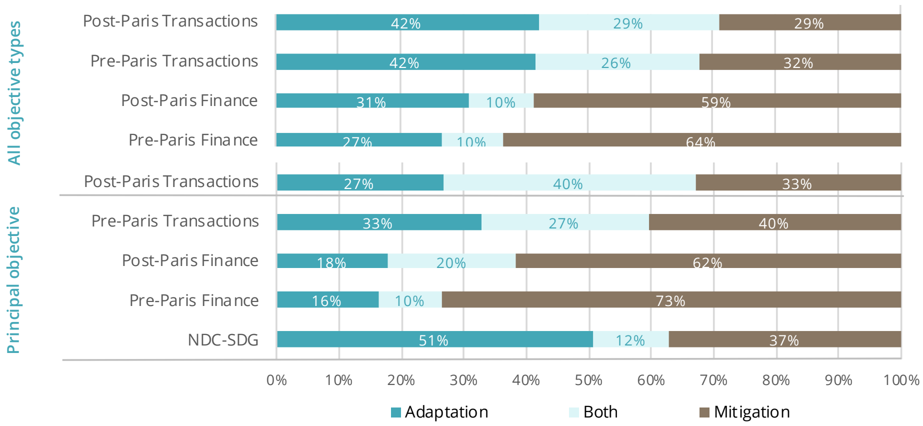

Figure 4.3 Share of DC climate activities and pre- and post-Paris climate-relevant finance and respective transactions by activity type (mitigation, adaptation, both). The top figure shows total climate-relevant finance and respective transactions for all objective types (principal, significant and climate components), while the bottom figure shows only climate-relevant finance and transactions where climate change was the principal objective.

transactions increases, but not for adaptation finance; the picture is also mixed for finance including all objective types. The lack of correlation for activities that are relevant to both mitigation and adaptation (marked as 'Both') are probably explained by the lack of common understanding and adequate reporting of activities that were equally relevant to both types of climate action. Moreover, even though NDCs are meant to be implemented from 2020 onward, in most cases they build on existing climate plans and strategies (e.g. Atteridge et al., 2020) and reflect interests that were already known to engaged donors.

Overall, while recipient countries put forward more adaptation-related activities in their NDCs, donors have so far committed more finance to climate mitigation (Figure 4.3). Based on the NDC-SDG Connections dataset, the analysed countries' have put forward a share of 51% climate activities related to adaptation and 37% to mitigation, with the remaining activities applying to both categories (12%)[34]. In contrast, climate finance shows a greater focus on mitigation, with shares of 64% and 59% (27% and 31% for adaptation) of all objective-type finance pre- and post-Paris respectively, and 73% and 62% (16% and 18% for adaptation) for principal objective. The allocation of transactions across the two types of climate action shows a more even balance both in the pre- and post-Paris period. Additionally, it also shows a much higher number of transactions that addressed both mitigation and adaptation.

34 This analysis excludes a share of 4% of all NDC activities in the NDC-SDG Connections dataset, as these were not defined by countries as mitigation, adaptation nor both.

Our analysis reveals that, despite visible changes in the post-Paris period, climate-relevant ODA still focuses considerably more on mitigation than on adaptation and is likely not adequately reflecting the Copenhagen Accord's call for a balanced allocation between the two. The large share of climate-change-mitigation finance relative to that of transaction indicates that some financed mitigation projects (such as building power plants) are costlier. Large infrastructure-related adaptation projects would make a similar difference, but the results indicate that the average cost of adaptation-related projects has been lower than for mitigation. The difference between allocations observed for all objective types relative to those of principal objective only suggests that climate mitigation is often the key climate priority of donors (especially pre-Paris), while adaptation is often a co-benefit. Moreover, this likely also reflects the greater challenge to differentiate between adaptation and development, and to determine its additionality (Funder et al., 2020). Nevertheless, as the principal objective excludes multilateral development banks due to their sole objection of including a 'climate component', the results probably also reveal that country donors are more focused on mitigation, while multilateral development banks likely strike a better balance. As discussed in the introduction, mitigation is a more attractive objective for donor countries for many reasons.

4.4.2 Global target-level analysis

Building on the previous analysis, we further assessed alignment of NDC activities and climate-relevant finance at a more granular level, specifically across SDG targets (c.f. Table 4.2 and Figure 4.4). Unlike the SDG-level, in the target-level analysis, we observe an increase in correlation coefficients from pre- to post-Paris for both finance and transactions under all and under principal objective. However, similar to the analysis at the SDG-level, these changes in correlation coefficients are rather small. On the other hand, we find that the correlation coefficients (with 124 degrees of freedom) for total climate-relevant finance and NDC activities at the SDG-target level are substantially lower than those related to the SDGs more broadly, although still moderately significant.

Table 4.2 Correlation analysis between recipient countries' NDC climate activities and climate-relevant finance and respective transactions. The analysis covers all types of climate activities (adaptation, mitigation, both, total) and all objectives as well as principal objective only, across all individual SDG targets. All correlation coefficients have p-value<0.001. The 124 degrees of freedom are given by the number of SDG targets included in the NDC-SDG Connections tool (i.e. all SDG targets that are not related to means of implementation (only those indicated by numbers and not by letters)).

	Finance (all)		Finance (principal)		Finance (all)		Finance (principal)	
	Pre-Paris	Post-Paris	Pre-Paris	Post-Paris	Pre-Paris	Post-Paris	Pre-Paris	Post-Paris
Correlation coefficient, (r(124)	0.65	0.66	0.64	0.69	0.53	0.55	0.58	0.61

Our results likely suggest that, while priority areas are matched between donors and recipients, there probably is less agreement on how these broad development areas ought to be addressed in concrete terms. Nevertheless, data-specific limitations were also important. For example, in Figure 4.4 we observe that, while NDC activities focus far more on SDG Target 2.4 (sustainable food production) than SDG Target 2.3 (increased agricultural productivity and farmers' incomes), a similar amount of finance and transactions were allocated between the two of them. Yet, the two targets can be linked, as sustainable food production could be used as a means to increase agricultural productivity and incomes. Therefore, considering that the assessed finance was climate relevant, most finance included under SDG Target 2.3 was in all likelihood also related to Target 2.4, applying sustainable and climate-smart agriculture to increase productivity and incomes. On the other hand, a negative relation can be seen between the less related SDG Targets 15.3 (degraded land and soil) and 15.2 (sustainable forest management). In this case, climate finance and transactions focused more on the former, while NDC activities speak more strongly to the latter. While tackling land degradation through forest management is possible, the link between the two targets is likely less strong than in the previous case. In contrast to these two examples, the allocation of finance across SDG Targets 7.1 (energy access), 7.2 (renewable energy) and 7.3 (energy efficiency) appear to be well aligned with the number of relevant climate activities in the NDCs, possibly due to the clear distinction between the three types of energy action.[35] One major limitation to this higher-resolution assessment was that the description of OECD finance sub-sectors

35 The mismatch between climate finance and NDC activities could also be caused by the use of primary targets only (see Annex A), as a small risk that some activities were included under secondary targets rather than primary targets in the NDC-SDG Connections dataset exists, and also that some were included under both, showing a larger number of activities for those targets where both primary and secondary actions are counted.

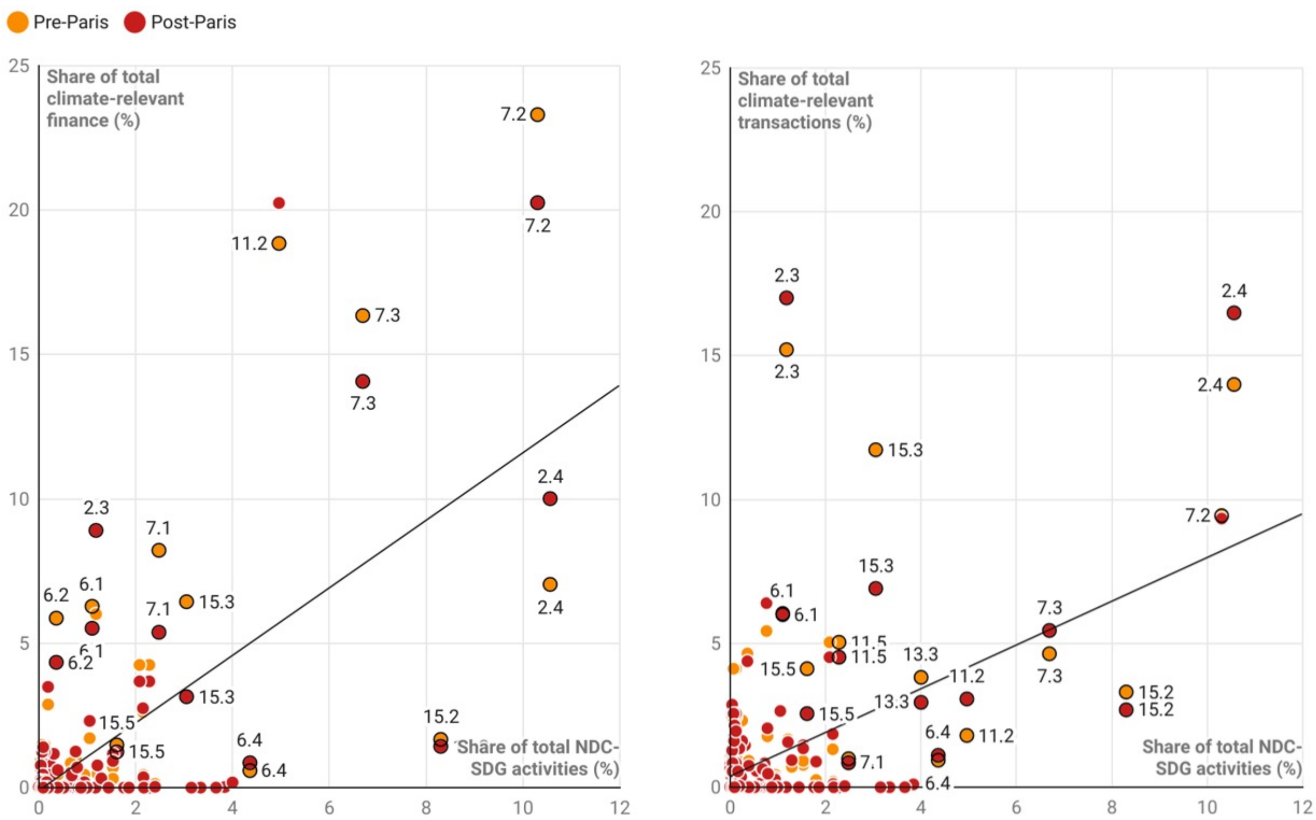

Figure 4.4 Share of countries' NDC climate activities relative to the share of climate-relevant finance and respective transactions. The analysis is conducted across all SDG targets, and covers all objective types of climate finance (principal, significant and climate component). The figure on the left hand side presents the analysis for climate-relevant finance, while the figure on the right hand side presents climate-relevant transactions.

is rather broad and not climate-specific. Therefore, while we included multiple targets of the same SDG to cover the description of the sector, each financial transaction was likely related to one or fewer of those targets. The NDC-SDG dataset was more accurate in that regard as it codes specific climate activities. Finally, reporting differences across finance sub-sectors within the same sector (i.e. same SDG) by individual donors was likely another limitation.

4.4.3 Country SDG-level analysis

Complementing our global-average analysis (i.e. overview of all NDCs), we have also investigated alignment for specific countries, whereby we matched received finance per country to the activities presented in each country. We find that for most SDGs, large shares of countries that put forward relevant NDC activities, have also had climate-finance commitments in those areas. This amounts to an average share of 71% for all objective types. The SDGs with the highest coverage in that sense were SDG2, SDG4 (education), SDG6, SDG7, SDG11, SDG13, SDG15 and SDG16 (peace and governance), while the areas that were addressed the least by donors were SDG5 (gender equality), SDG10 (reduced inequality), and SDG12 (natural resources). These results show that there tends to be a better match for those SDGs that both donors and recipients deemed important, as shown in the previous section, and a lower match for those SDGs that had lower shares in both finance and activities. Nevertheless, while we observe similar prioritization of SDGs for principal objective type of finance, the average shares of recipient-donor matching are lower (i.e., only 49% and 46% in pre- and post-Paris, respectively; Table 4.3). These results suggest that, although ODA may not always address priority climate areas directly (i.e., as principal objective), they seek to create climate co-benefits in those areas through development projects of other principal objectives. Nevertheless, SDG2, SDG6, SDG7, SDG13 and SDG15 are also strongly covered by principal objective finance, highlighting once more the particular importance of these areas to climate change.

In contrast, most countries (60%-63% on average) that have not put forward climate activities in a specific SDGs, have received climate-relevant ODA of all objective types for that SDG with a lower share for principal objective (35%-40% on average). These results likely reflect several aspects: 1) the variation in comprehensiveness of NDCs; 2) the different interests of donors concerning SDG areas of climate relevant; 3) a potential interest to frequently report climate co-benefits (in all objective types) to increase the reported total climate-relevant finance; 4) 'climate component' projects of multilateral development donors likely close part of the gap observed between 'principal objective' and 'all objective types'.

Table 4.3 This table shows the match between countries NDC activities and climate-related ODA. It presents: 1) the share of countries that put forward NDC activities relevant to a specific SDG and have received climate-relevant ODA for that specific SDG areas (i.e. 'NDC (yes) – Fin. (yes)'); 2) the share of countries that did not put forward NDC activities relevant to a specific SDG and have not received climate-relevant ODA for that specific SDG areas (i.e. 'NDC (no) – Fin. (no))'. These shares are shown for the pre- and post- Paris periods and for finance covering all objective types (i.e. 'All types') or only principal objective (i.e. 'Principal'). The last column shows the average share across all SDGs.

a) SDG 1-9

		Sustainable Development Goals	1	2	3	4	5	6	7	8	9
All types	Pre-Paris	NDC (yes) - Fin. (yes)	77%	93%	79%	91%	49%	97%	98%	66%	76%
		NDC (no) - Fin. (no)	37%	35%	31%	12%	76%	4%	0%	52%	44%
	Post-Paris	NDC (yes) - Fin. (yes)	75%	94%	71%	91%	46%	93%	95%	74%	86%
		NDC (no) - Fin. (no)	50%	15%	41%	24%	71%	4%	0%	37%	39%
Principal	Pre-Paris	NDC (yes) - Fin. (yes)	44%	78%	44%	59%	11%	85%	93%	18%	50%
		NDC (no) - Fin. (no)	71%	70%	76%	44%	96%	23%	6%	81%	67%
	Post-Paris	NDC (yes) - Fin. (yes)	19%	80%	48%	56%	15%	74%	83%	21%	48%
		NDC (no) - Fin. (no)	77%	60%	73%	48%	91%	38%	12%	89%	83%

b) SDG 10-17 and the average share across all SDGs (last column)

		Sustainable Development Goals	10	11	12	13	14	15	16	17	Avg.
All types	Pre-Paris	NDC (yes) - Fin. (yes)	0%	87%	0%	96%	57%	99%	84%	55%	71%
		NDC (no) - Fin. (no)	100%	29%	100%	6%	59%	0%	8%	40%	37%
	Post-Paris	NDC (yes) - Fin. (yes)	4%	89%	2%	91%	55%	94%	95%	49%	71%
		NDC (no) - Fin. (no)	98%	13%	100%	24%	67%	20%	11%	60%	40%
Principal	Pre-Paris	NDC (yes) - Fin. (yes)	0%	60%	0%	84%	24%	99%	58%	24%	49%
		NDC (no) - Fin. (no)	100%	79%	100%	6%	88%	0%	36%	70%	60%
	Post-Paris	NDC (yes) - Fin. (yes)	0%	60%	1%	81%	16%	92%	74%	12%	46%
		NDC (no) - Fin. (no)	100%	63%	100%	24%	94%	25%	32%	100%	65%

When analysed by income group[36], the NDC-SDG Connections dataset presents the largest number of activities in lower middle income countries (i.e. 39%) followed by low income and upper middle income countries with 30% and 25% respectively. These shares are closely reflected by the distribution of climate-finance transactions, respectively 30%, 41% and 27% for low income, lower-middle income and upper middle income countries. In total, we analysed 24% low income countries, 32% lower middle income and 36% upper middle income. However, the share of overall finance between country income groups is even more strongly skewed towards lower middle income countries (i.e. 52%, followed by upper-upper middle income

36 Based on the World Bank 2019 economic groups classification: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

countries with 30%). Overall, low-income countries have only received 14% of the finance[37]. The difference between the distribution of finance relative to transactions likely indicates that middle income countries can absorb more finance in larger-scale projects than low income countries. However, recent research shows that although low income countries have generally received less climate-relevant ODA support per capita in the past than lower-middle income countries, they have comparable conditional per-capita greenhouse gas emissions reduction pledged in the NDCs (see Chapter 3). This suggests a high interest and high potential for future climate change mitigation in low-income country, provided adequate international support. Nonetheless, climate finance needs to be substantially ramped-up in order to meet the conditional requests of countries NDCs - failure to do so poses the risk of underachievement of pledges (Pauw et al., 2020; Sforna, 2019).

4.5 Conclusions

Transitioning to a low-carbon and climate-resilient world and staying below a maximum temperature increase of 1.5°C or even well-below 2°C, require deep changes across all economic sectors with impacts across the SDGs. Moreover, climate change itself will have substantial negative implications for development. In that sense, climate action and sustainable development are strongly interconnected and this is clearly reflected in countries' NDCs, which put forward climate activities that span across all SDGs.

This highlights the potential of climate-relevant ODA to jointly address both climate and sustainable development. Yet, the extent to which donors make use of this potential and how their focus aligns with recipients' priorities have not been the subject of detailed empirical analysis to date. Our study aimed to contribute to these debates. To that end, we assessed which SDGs climate-relevant ODA has contributed to in the years prior to and after the Paris Agreement and how these contributions compare to recipient countries' planned NDC activities across two key dimensions: SDGs, including their targets; and climate adaptation and mitigation.

First, we found that donors' climate-relevant finance contributes to multiple SDGs. In particular, SDG7 (energy) and SDG11 (cities) were highly supported, but also SDG2 (agriculture), SDG15 (life on land) and SDG6 (water). On the one hand, this observed distribution signifies well the mitigation potential in these respective areas and the need for stronger resilience and adaptation as the climate continues to change. On

37 This distribution remained relatively steady between pre- and post-Paris periods.

the other hand, this finding also highlights areas of untapped potential, for instance in the economic and industrial SDG8 (jobs and economic growth), SDG9 (industry and infrastructure), SDG12 (sustainable production and consumption) and the social SDGs dealing with poverty (i.e. SDG1) and inequalities (i.e. SDG5 and SDG10). Uncovering the extent to which donors' climate-relevant finance simultaneously supports SDG implementation reveals how synergies between the Paris Agreement and the 2030 Agenda are currently leveraged. Awareness of this potential can motivate higher support for climate action and a more coherent and effective use of development assistance.

Second, we found that substantial alignment exists between donors' and recipients' priorities at the SDG level, but that this alignment has not improved in recent years. This is highly relevant, as aligning climate finance with countries' priorities can enhance ownership of recipient countries and would result in a more efficient use of limited financial resource. However, we do not find a shift towards more alignment between NDC activities and climate-relevant finance in the post-Paris period as compared to the pre-Paris period. This suggests that the release of the NDCs did not have an observable effect on donor-recipient priorities alignment. Moreover, in line with the literature, our findings show that low income countries put forward a larger number of activities compared to middle income groups, despite having received less climate-relevant finance per capita. Stronger support for these countries, which tend to have higher conditional greenhouse gas per capita reductions targets, could ensure a higher chance of success for the Paris Agreement. For the SDG-targets, we found a more limited alignment of priorities. In general, misalignment could be a result of various aspects: donors follow their own interests (geopolitically, economically or for the global common good) and their own judgement of what development areas merit attention (including based on constituencies approvals); a lack of clarity of recipients' needs and priority emerges or a mismatch in what is communicated beyond the NDCs. Our analysis helps identify key gaps and opportunities for further alignment of climate and sustainable development action.

Third, our assessment shows that, although countries include more climate-change adaptation actions in their NDCs than mitigation actions, more climate-relevant finance is allocated to climate-change mitigation than to adaptation. This indicates a lack of alignment not between donor and recipient priorities. Moreover, although a 'balanced' allocation requirement was never concretely defined as 50/50, the observed allocation of climate-relevant ODA is likely not representative of such a requirement, in particular in the pre-Paris period (when the allocation was 73% to mitigation and 16% to adaptation for finance with climate change as principal objective). Nevertheless, our data shows that donors' allocation of climate-relevant

ODA has become more evenly I split in the post-Paris period, although with a continued emphasis on mitigation. In the climate negotiations, developing countries have always seen adaptation as a high priority that is underfunded. A better understanding of what causes this imbalance, beyond the likely interest of donors in the global common good of GHG emissions reductions, is needed.

Improving the alignment of climate-relevant financial support with sustainable development priorities of recipients likely helps to increase acceptability of external projects, to enhance the sense of ownership and to attract more private finance. Our study shows that substantial room for improvement on aligning priorities between donors and recipients still remains and that this alignment was not improved through the publication of the NDCs. Future climate-relevant ODA planning could more closely take into account developing countries' needs based on their NDCs or through bilateral dialogues. Nevertheless, while ODA offers a great opportunity for leveraging co-benefits between climate and sustainable development actions, the risk of over-reporting should be addressed. To that end, clear standards of what counts as climate finance must be set in place globally through the UNFCCC processes. This would facilitate improved policy-making and research endeavours.

Our findings contribute to several research streams. They feed into discussions on: raising climate ambition; the conditionality and feasibility of NDCs; policy coherence in implementing the Paris Agreement and the 2030 Agenda; ownership of climate action in developing countries; and aid effectiveness and efficient use of climate-relevant finance. We highlight the large potential of climate finance to contribute to other sustainable development areas and vice versa. A better alignment and a focus on maximizing synergies between climate and the SDGs could improve the efficient and effective use of development finance in the future, and thus, achieve more with less. Current UNFCCC expert discussions on the assessment and determination of needs of developing countries under the Paris Agreement highlight that such assessments must address not only the needs but also the support received in order to determine remaining gaps. As the effects of dangerous climate change looming ever closer and the implementation of the Paris Agreement and the 2030 Agenda lagging behind, our study shows that substantial untapped potential could be unlocked through further climate-development integration and priorities alignment.

Extreme weather events and changes in rainfall patterns affect agriculture.
Photo taken in Village in Bhutan, 2015.

Extended droughts lead to food insecurity.
Photo taken in San Juan, Bolivia, 2014.

5

Transitioning to low-carbon economies under the 2030 Agenda

Minimizing trade-offs and enhancing co-benefits of climate action for the SDGs

This chapter is based on:

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Abstract

The 2030 Agenda with its Sustainable Development Goals (SDGs) and the Paris Agreement on climate change were adopted in 2015. Although independently defined, the two agreements are strongly interlinked. In that sense, the transformative nature of low-carbon transitions sets the imperative for a clear overview of climate-action impacts on other development areas and of ways to address these impacts. We developed a framework that scores impacts of climate-change actions on all SDG targets based on directionality (i.e. trade-offs or co-benefits) and likelihood of occurrence (i.e. ubiquitous or context dependent), and categorizes them by dependence on four key context dimensions – geographical, governance, time horizon and limited natural resources. We applied this framework to 33 key types of climate-change mitigation policies and 53 development areas. Through an extensive literature review, we found that climate-change mitigation measures directly affect 15 out of 17 SDGs and 94 out of 124 SDG outcome targets. The identified impacts are mostly co-benefits, suggesting a high potential to simultaneously tackle climate-change and development issues. Improving energy efficiency, reducing energy-services demand and switching to renewables provide most co-benefits. In contrast, carbon capture and storage and nuclear energy likely lead to multiple trade-offs. We show that understanding the relevant context dimensions facilitates policy design and policy mixes that enhance co-benefits and minimize trade-offs. In general, the choice of location and governance approach are the most frequent context dimensions that influence climate-change and SDG interactions. Finally, by assessing the prevalence of climate-change mitigation measures in G20 countries, we found that measures with more co-benefits tend to be more frequently adopted. Our study advances the knowledge of climate–SDG interactions, contributing to climate and sustainable development governance research. Moreover, the developed climate-change–SDG scoring framework facilitates policy design in view of a joint implementation of the Paris Agreement and Agenda 2030 nationally and internationally.

5.1 Introduction

The Paris Agreement (UNFCCC, 2015) on climate change and the 2030 Agenda (UN, 2015) on sustainable development[38] are two major international agreements that were adopted in 2015 by parties under the United Nations Framework Convention of Climate Change (UNFCCC; Paris Agreement) and the United Nations General Assembly (2030 Agenda), both covering most of the world's countries. The Paris Agreement's main goal is to limit global temperature increase to well below 2°C and to strive for a limit of 1.5°C, while managing unavoidable climate-change impacts. The 2030 Agenda, on the other hand, covers a wide range of social, economic and environmental issues represented through a set of 17 Sustainable Development Goals (SDGs) and 169 respective targets. Both agendas are universal in nature, meaning that all countries must take action towards the achievement of these common goals.

Although developed independently, the Paris Agreement and the 2030 Agenda are strongly interlinked. First, the 2030 Agenda directly addresses climate change through SDG 13. Second, the Paris Agreement emphasizes the importance of sustainable development considerations when addressing climate change. Third, climate change itself is recognized to hinder development efforts worldwide (Hoegh-Guldberg et al., 2018; Roy et al., 2018). At the level of implementation, climate-change measures have numerous direct and indirect (i.e. second order) impacts on most other development areas and related SDGs (Dzebo et al., 2019; ICSU & ISSC, 2015; Roy et al., 2018; Shawoo et al., 2020; von Stechow et al., 2015, 2016). Likewise, the means of reaching various SDGs most often affect future greenhouse gas (GHG) emissions levels (Randers et al., 2019; UNEP, 2016). Importantly, countries' Nationally Determined Contributions (NDCs), which are the main national implementation strategies of the Paris Agreement, put forward climate-relevant actions[39] that are directly linked to all SDGs (Dzebo et al., 2017; Janetschek et al., 2020).

The links between climate and development actions have been studied for decades (Nordhaus, 1977), motivated by the importance of climate-change policy integration with the traditional development agenda (Beg et al., 2002; Rob Swart, 2003). Hence, a large body of literature addresses climate–development synergies and trade-offs. While some studies undertake comprehensive climate–development assessments

38 In this study we refer to 'sustainable development' in the context of the 2030 Agenda, but we use a broader understanding of 'development', as a multitude of social, economic and environmental objectives that may not always individually align with sustainability objectives.

39 We refer to 'climate[-change/relevant] action' as state and non-state policies and measures that have the effect of addressing climate change (whether intentionally or not (i.e., climate-change relevant)).

(IPCC, 2014; Kok et al., 2008; von Stechow et al., 2015, 2016b), others focus on the nexus between climate-change actions and individual development areas, such as air quality (Bollen et al., 2010; Braspenning Radu et al., 2016; Maione et al., 2016), food security (Fujimori et al., 2018; Hasegawa et al., 2018), energy security (Bollen et al., 2010; Guivarch & Monjon, 2015), energy poverty (Chakravarty & Tavoni, 2013; Solaymani et al., 2015; Ürge-Vorsatz & Tirado Herrero, 2012) or energy more broadly (Mccollum et al., 2018; Nerini et al., 2017).

More recent studies have analysed the impacts of climate change and climate-change actions on the SDGs specifically, both for climate-change mitigation (reducing GHG emissions) and for climate adaptation (addressing climate-change impacts) (Nerini et al., 2019; Roy et al., 2018). Among these studies, the SCAN-tool[40] built on an earlier version of the impact analysis presented as the first step in our study (Gonzales-Zuñiga et al., 2018). These studies typically use literature review and expert judgement to classify climate-change—SDG interactions based on numerical scales that indicate trade-offs and co-benefits, and the strength or nature of the interactions. Such analyses and classifications have elucidated a wide breadth of climate-change—SDG interlinkages and have highlighted that, although most interlinkages represent co-benefits, there are also important trade-offs that could undermine achieving either the climate or the SDGs.

Focusing on climate-relevant policies and measures that are firmly within the national sustainable development priorities of countries, is essential to ensure that climate-change and development policy coherence[41] is achieved and goals are jointly reached (Winkler et al., 2008, 2015). As such, the choice of low-carbon transition pathways to mitigate climate change is highly important as this determines whether other development objectives are met (von Stechow et al., 2016b). Yet, while existing literature provides mostly comprehensive overviews of climate and development interlinkages, available classifications are not explicit on the implementation contexts of interlinkages and how these will favour different policy approaches. The need for a better understanding of such contexts was emphasised early on in the SDG interlinkages classification literature (e.g. Nilsson et al., 2016) and later elaborately explained (Nilsson et al., 2018).

In our study, we review the literature on climate and development links to systematically identify (possible) direct policy impacts of 33 climate-change mitigation areas and technologies on 53 relevant development areas and respective SDG targets.

40 SDG Climate Action Nexus tool (SCAN-tool), https://ambitiontoaction.net/scan_tool/

41 Policy coherence is defined by the OECD (2018, p. 83) as “matching of policies, processes and institutions at all government and governance levels to avoid contradictions and trade-offs in policy making.”

Our mapping of these impacts differs from and adds to previous literature in the following: 1) it categorizes climate-change—SDG linkages by specific development areas, some of which cut across multiple SDGs and SDG targets; 2) it addresses each type of renewable energy technologies separately under the measures for low-carbon fuel switch; 3) it includes the impacts of energy taxation and of CO_2 taxes in the energy and agriculture sectors; and 4) it applies a scoring method that focuses on whether policy impacts occur at all times or only in specific circumstances. The last point is of particular policy relevance as this indicates whether complementary policies or policy designs could be used to manifest co-benefits (i.e., when they only occur under specific circumstances) or only to enhance these impacts (i.e,. if they always occur with the respective climate measure). Similarly, in the opposite direction, our analyses will indicate whether trade-offs could be avoided altogether or whether they can only be reduced.

Most importantly, we address the key gap of implementation-context effects on climate-change—SDG interlinkages by classifying all identified policy impacts across the context dimensions adapted from Nilsson et al. (Nilsson et al., 2018): time horizon, geographical (local), governance and natural resources (the latter being added to their three dimensions). These four context dimensions provide additional information about these impacts and elucidate concrete types of policies and policy designs that could be used to maximize co-benefits and minimize trade-offs. In this sense, we built a comprehensive and highly informative database of climate-change and SDG policies and their impacts, and respective context dimensions, which would score and categorise benefits of and trade-offs between climate-change mitigation and development policies. Its output should inform policy-making processes and enhance policy coherence between climate and development objectives.

Finally, we consider the climate-change mitigation measures currently implemented in the G20 member countries to assess potential preferences for specific types of climate measures and respective development impacts. This assessment acts as an example of a potential application of the developed Climate-change—SDG scoring framework and helps to determine to what extent policy coherence is already addressed in some of the largest GHG emitting countries. Jointly, the G20 countries were responsible for 75% of global GHG emissions in 2018, including land use and land-use change (Nascimiento et al., 2021).

As countries are currently developing more ambitious NDCs under the Paris Agreement and sustainable development strategies to concurrently achieve the 17 SDGs, a good understanding of climate-change—SDG interlinkages and ways to enhance policy coherence or respective strategies are essential. Our impact classification approach could support relevant state and non-state actors, and researchers who address issues of climate-change—development policies integration and institutional cooperation for jointly implementing the Paris Agreement and Agenda 2030. Moreover, our approach could also be applied to assess the impacts of measures related to any other development area, not only climate change.

5.2 Methods

The scope of our study extends to relevant climate-mitigation measures across all economic sectors (electricity and heat, industry, buildings, transport, agriculture and forestry) and all relevant SDGs. In that sense, it covers policy instruments from a wide range of policy areas: the switch to low-carbon energy production sources (including in the transport sector), assessed by source; changing activities or behaviours that reduce demand for energy and materials; energy efficiency improvements; non-energy related measures that reduce GHG emissions, in particular in the industry sector; energy taxes and CO_2 taxes in the energy and agricultural sectors; agricultural, forestry and other land-use measures (AFOLU), including reduction in livestock consumption; and education, training and awareness raising. The analysed set of policy measures was adapted from previous reports of the Intergovernmental Panel on Climate Change (IPCC) (IPCC (2014), Table TS.3, and Roy et al. (2018), Table 5.2). However, it ignored measures that require international cooperation such as ocean enhanced weathering, ocean fertilization or other types of geoengineering. We only considered policies and measures that are commonly implemented with the objective to reduce GHG emissions, and not also more general economic and social reforms that would affect GHG emissions indirectly. The complete list of climate-change policies and measure is presented in the following section, along with the results. Concerning development areas, this study addresses all SDGs and their respective targets, with the exception of targets that address 'means of implementation' and of SDGs 16 (promote just, peaceful and inclusive societies) and 17 (partnerships), which focus on governance approaches rather than development outcomes.

The first step in our study was to conduct a thorough review of both academic and grey literature to identify a wide range of development impacts of climate-change mitigation measures. We started from existing reviews of climate-change mitigation impacts on development and extracted all relevant impacts and cited studies (ICSU & ISSC, 2015; IPCC, 2014; Roy et al., 2018). Next, we conducted a systematic search for other relevant literature in Google Scholar (to capture both scientific and grey literature) through the use of keywords that related to specific climate-change mitigation measures (listed above) and the broader SDG development areas. In addition, the text of the SDG targets was analysed to identify more specific development areas that could be affected by climate-change mitigation measures, based on the authors' judgement, and that did not appear in the initial literature. These potential new impact areas were used to further refine and deepen the literature search. The abstracts of papers with relevant titles were read in full. Where the abstracts showed high relevance, the full papers were consulted and the relevant development impacts were extracted. Beyond broader literature on climate-change—development impacts, we also used empirical analyses and qualitative case studies relevant to the development impacts assessed to fill the literature gaps. The objective of this exercise was to identify all potential climate-change—development impacts and not to assess the level of scientific consensus or to provide a complete account of the literature. Therefore, we only highlight key exemplifying literature on each impact. The literature review process is further described in Figure 5.1.

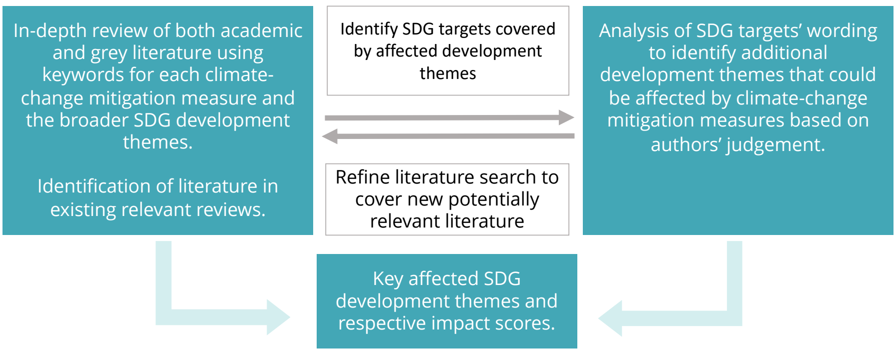


Figure 5.1 Methodological approach used to identify the key SDG development areas affected by assessed climate-change mitigation measures.

The complete list of 53 development areas and corresponding SDG targets that were identified in our literature review of climate-development interactions is presented in Table 5.1. Due to the interlinked nature of the SDGs, some key development areas are recurrent and appear in more than one SDG target. For example, air pollution is part of targets on cities (SDG11), health (SDG3), and responsible consumption and production (SDG12).

The identified interactions between climate-change mitigation measures and specific development areas were scored from -2 to 2 based on impact direction (trade-offs/co-benefits) and the dependence of impact occurrence on the local context or the implementation approach (Table 5.2). The most widely used scoring method for SDGs interactions so far is the seven-tier scale developed by Nilsson et al. (2016), which was applied, for instance, by Roy et al. (2018) and Nerini et al. (2019) for climate-change mitigation measures, by McCollum et al. (2018) for SDG7 (energy), by Coopman et al. (2016) for SDG 12 (sustainable production and consumption) and by ICSU (2017), Nilsson et al. (2017) and Weitz et al. (2017) to a variety of SDGs. However, as our study does not assess bi-directional interactions between SDGs, nor indirect interactions, but rather focusses on the direct impacts of different types of climate-change mitigation measures on all other SDGs, we could apply a narrower scale. Moreover, as the dependence of an impact on the context or implementation approach can inform whether the impact can be fully or only partly addressed, our scale additionally provides information on the impact occurrence dependence.

Table 5.1 Identified development areas affected by climate-change mitigation and their corresponding SDG targets. The symbols indicate if the respective development area is primarily of economic (diamond), social (circle) or environmental nature (square). Some development areas are relevant to more than one of these three dimensions, but we only highlight the most predominant.

Development theme	SDG targets	Development theme	SDG targets
◆ Affordable energy (poverty)	1.2, 7.1, 11.1	◆ Economic diversification	8.2, 8.3, 9.5
● Energy access	1.4, 7.1, 11.1	◆ Tech./infrastructure upgrade	8.2, 9.5
● Land access	1.4, 2.3	◆ Economic productivity	8.2
● Food availability	2.1	◆ Decent/safe jobs	8.3, 8.8
◆ Agricultural jobs	2.3	■ Resource efficiency	8.4, 9.4, 12.2, 12.5
◆ Agricultural productivity	2.3, 2.4	■ Growth w/out env. degradation	8.4
◆ Farmers' income	2.3	◆ Job creation	8.5
◆ Agri. infrastructure/knowledge	2.3	◆ Sustainable infrastructure	9.1, 9.2
◆ Resilient and sust. agriculture	2.4	◆ Sustainable industrialization	9.2
● Communicable diseases	3.3	◆ Inclusive industrialization	9.2
● Non-communicable diseases	3.4	◆ Bottom 40% income growth	10.1
● Mental health	3.4	● Inclusiveness	10.2
● Road safety	3.6, 11.2	● Adequate housing	11.1
■ Non-thermal water pollution	3.9 ,6.3, 14.1	● Affordable housing	11.1
■ Air quality	3.9, 11.6, 12.4	● Public transport	11.2
■ Soil quality	3.9, 12.4, 15.3	■ Sustainable transport	11.2
● Training and education	4.3, 4.4, 4.5, 4.7, 12.8	■ Sustainable settlements	11.3
● Female discrimination	5.1	■ Ecosystems/nature	11.4, 15.1, 15.5
● Domestic work support	5.4	■ Environmental impact of cities	11.6
● Water efficiency & access	6.1, 6.4	■ Waste management	11.6, 12.5
■ Thermal water pollution	6.3, 14.1	■ Sust. corporate practices	12.2, 12.6
■ Water ecosystems	6.6, 15.1	■ Sust. forest management	12.2, 15.2
● Modern energy sources	7.1	■ Food waste	12.3
● Reliable energy	7.1	■ Sust. public procurement	12.7
■ Renewable energy	7.2	■ Coastal ecosystems protection	14.2, 14.5
◆ Energy efficiency	7.3	◆ Marine economies	14.7
◆ Sustained economic growth	8.1, 8.3		

Table 5.2 Scoring method for (climate-change mitigation) policies and measures impacts on SDGs

2	1	0	-1	-2
This action always leads to the specified co-benefit. This impact can be enhanced by addressing the relevant context dimensions.	This action can lead to a co-benefit. This impact can be manifested and enhanced by addressing the relevant context dimensions.	The action can lead to a co-benefit or a trade-off. Favourable outcomes can be pursued by addressing the relevant context dimensions.	This action can lead to a trade-off. This impact can be reduced or completely avoided by addressing the relevant context dimensions.	This action always leads to a trade-off. This impact can be reduced by addressing the relevant context dimensions.

An example of climate-change—development impact that would occur under any circumstance is, for instance, the resulting air pollution reduction if fossil fuel power plants are replaced by solar photovoltaics (PV). An impact that would occur only under specific circumstances is, for instance, the displacement of local communities as a result of hydropower projects. This would occur only if communities exist in the area where projects are implemented. An understanding of the impact context dependence informs policy makers with regard to the space of action available. More precisely, the scoring indicates whether trade-offs could be fully eliminated (-1, 0) or only attenuated (-2), and similarly, whether certain enablers are necessary to obtain specific co-benefits (0, 1) or whether those co-benefits are always attained and further action could be taken to enhance them (2).

Nevertheless, the occurrence and strength of the impacts of climate-mitigation measures are strongly dependent on a country's development context and on the way in which these measures are actually implemented. Beyond simple scoring of interactions, Nilsson et al. (Nilsson et al., 2018) point out that "to support policy efforts at appropriate levels of decision-making, the contextual dimensions must be front and centre of the assessment process" (page 1491). In that regard, they identified their three key dimensions.

We categorize all SDG impacts based on our four dimensions (time horizon, geographical, governance and natural resources). This categorization aims to add depth to the original scoring framework, and to add value to policy design and decision making on policy mixes and instrument selection by better understanding the nature of policy impacts. The context dimensions show that impacts of climate-change mitigation measures are influenced by 'when', 'where' and 'how' they are implemented within the country, and by 'what' limited natural resources are available in the country overall. The context dimensions were defined as follows:

Time horizon (*when*)

Indicates that a policy impact may manifest in the opposite direction in the short term as opposed to the long term;

Local (geographical) (*where*)
Indicates that the policy impact's occurrence or magnitude would be influenced by the location where a specific project is implemented, or where a measure takes effect;

Governance (*how*)
Indicates that the policy impact occurrence and magnitude relates to the implementation approach through: choice of technology or (guidelines on) processes, or applicability of policy. This dimension does not cover governance effectiveness or other aspects of governance; and

Natural resources (i.e. limited fuels) (*what*)
Indicates that the policy impact occurrence and magnitude depends on availability of limited natural resources nationally (in particular fossil and radioactive fuels). This category does not include renewable energy resources, which are covered in the 'local' context dimension.

In our analysis, we only considered direct (first-order) impacts of climate-change mitigation policies and measures. Indirect impacts of climate-change mitigation measures (i.e. second order impacts) and the impacts of climate change per se were excluded from the assessment to avoid double-counting of SDG linkages and to maintain the focus on climate-change policies and actions. For instance, the use of renewable energy sources for GHG emissions reduction can facilitate expansion of electricity in remote areas and help achieve the SDG 7 target on electricity access (direct impact). In turn, increased access to electricity can further become an enabler for improved education, access to health services and increased economic activities, among others. In our study, only the impact on SDG 7 would be indicated, as a direct impact.

Moreover, as we aim to analyse the impacts of climate-change mitigation, we assumed that the climate measures would reduce GHG emissions. Hence, where applicable, we assumed that these measures would replace or reduce the use of higher-carbon fossil fuel energy (e.g. natural gas replaces coal) and scored the impacts relative to such a fossil-fuel alternative. These assumptions are necessary to distinguish between the impacts of a carbon-intensive versus those of a climate-mitigation scenario, hence, assessing the co-benefits and trade-offs of a low-carbon transition.

In the final part of our study, we use data on climate-change mitigation policies and measures currently in force in the G20 member states (including the European Union as one and excluding individual EU member states due to insufficient data) to determine which types of policies and measures are more frequently adopted by these countries. Here we focus on the same policy types, instruments and sectors as in the first part. We assume that types of climate measures that predominantly offer co-benefits, would be favoured by more countries and therefore assess a potential correlation between the overall number of positively affected SDG targets as weighted by the score given in the scoring framework, and the number of G20 member states that adopted these measures. The data on climate-change mitigation policies and measures in these countries was extracted from the Climate Policy Database[42], based on the 2020 update by (Nascimiento et al., 2021).

5.3 Results and discussion

In this section we present the identified impacts of climate-change mitigation measures on other SDGs, including their scoring and categorization across the context dimensions. While here we only show the overarching results of our analysis, we provide an extensive textual description of the SDG impacts, based on our literature review, in the Supplementary Material for Chapter 5. Moreover, in the submitted version of this chapter we included an Excel-format Supplementary Material that is designed to act as a research and policy tool. In this Excel file, all impacts are presented in a comprehensive interactive table that indicates the impact scores and context dimensions and provides descriptive information on the impacts in pop-up boxes. Finally, we present the results of the G20 climate-change policies analysis to shed light on how climate-development impacts determine policy preferences.

5.3.1 Identification of climate-mitigation impacts on the SDGs

We found that climate-change mitigation measures affect the SDGs in many different ways, but mostly through co-benefits. The overview of impacts presented in Figure 5.2 shows that measures that improve energy efficiency and those that reduce demand for material and energy services through strategic planning and change of activities and processes (i.e. changing activities), mainly result in co-benefits across

42 Climate Policy Database, climatepolicydatabase.org. This database is maintained by NewClimate Institute with support from PBL Netherlands Environmental Assessment Agency and Wageningen University and Research

all SDGs. Furthermore, when compared to fossil-fuel alternatives, renewable energy sources also have mostly co-benefits, especially for solar PV, tidal and wave energy, solar and geothermal heating, and wind. Consequently, if fuelled by clean energy sources, electric vehicles (EVs) would also predominantly provide co-benefits, although some trade-offs remain, such as battery production and disposal.

Nevertheless, trade-offs of climate-change mitigation are most often the deal breakers of ambitious climate-change policies and actions and require special attention when designing climate-change strategies. Nuclear energy and (bioenergy) carbon capture and storage ((BE)CCS), followed by natural gas and biofuels are climate-change mitigation measures with a larger number of trade-offs across most development areas analysed. In fact, CCS (applied to fossil fuel energy production) has the lowest overall score when impact scores are summed across all relevant development areas[43] (Figure 5.2) and it is the only other climate-change mitigation measure with a negative overall score next to energy/CO_2 and agriculture taxes. Although CCS and BECCS apply similar technologies, (fossil fuel) CCS continues all trade-offs related to fossil fuels and adds to them through increased energy demand for system operation. Nevertheless, while CCS requires additional energy to reduce the impacts of fossil-fuel-energy production, BECCS provides the benefit of a carbon sink and can, therefore, be counted as productive energy use. Similarly, industrial carbon capture and utilisation would increases the productive use of energy and could further improve water-use efficiency if its processes are optimized (Brandl et al., 2017). Energy and agricultural (CO_2) taxes are also broadly conflicting with other SDGs, especially with poverty alleviation (SDG 1), if the resulting high energy prices are not subsidised or taxes are not exempted for poor households (Cameron et al., 2016; Hirth & Ueckerdt, 2013).

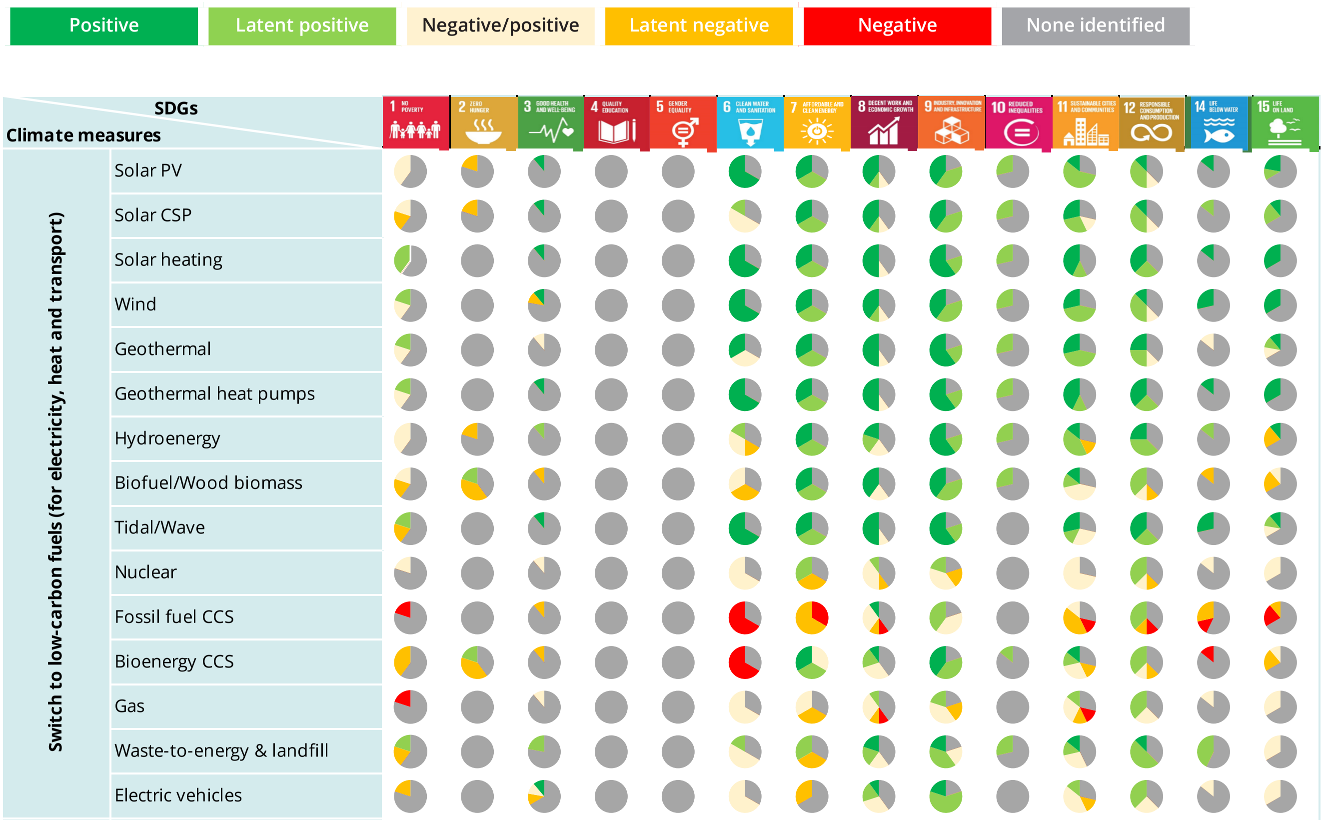
Identified direct climate-development impacts cover a large share of SDG targets (Figure 5.2). Most affected SDGs through either trade-offs or co-benefits are 6 (clean water and sanitation), 7 (affordable and clean energy), 8 (decent work and economic growth), 9 (industry, innovation and infrastructure), 11 (sustainable cities and communities) and 12 (responsible consumption and production). Additionally, SDG 2 (zero hunger) has a high target coverage under biofuel and agriculture-related climate measures. The trade-offs of CCS, BECCS and nuclear are most prominent for SDGs 1 (poverty eradication), 6, 7, 8, 11, 14 (life under water) and 15 (life on land). SDGs 4 (quality education), 5 (gender equality) and 10 (reduced inequalities) are lar-

43 By overall score we mean the direct addition of all scores of a given measure. Hence, if a measure has more co-benefits (i.e., more positive score +1 and +2) than trade-offs (i.e. negative scores such as -1 and -2), it will have a positive overall score. In general, a larger number of co-benefits would result in a higher the score.

gely unaffected by climate-change mitigation measures based on our analysis, as we focus solely on direct impacts. In general, economic and environmental development areas (see Table 5.1) and respective SDG targets are affected by more climate-mitigation impacts than social development areas. However, if indirect impacts were included, a higher coverage would be observed across SDGs. Future research could apply our scoring framework to assess direct interactions of other SDG targets and ultimately link impacts of all SDGs to help reveal indirect connections across SDGs (Nilsson et al., 2018).

While our scoring approach signifies well all the climate-development interactions across SDGs, further research is needed to indicate the magnitude and relevance of impacts in a country and local context. Nilsson et al. (Nilsson et al., 2016) already highlighted the dangers of generalization and the need to interpret impacts based on a country's context. For instance, the risk posed by biofuels to food security would primarily affect countries that are prone to food insecurity. Similarly, poverty-related impacts of energy (CO_2) taxes would be especially relevant in countries with high poverty rates. In a country-case study of Sweden, Weitz et al. (Weitz et al., 2017) showed how impact-scoring frameworks can be used to determine interactions between SDGs based on a country context. Furthermore, we assumed that climate measures would replace a more GHG-intensive option or reduce fossil-fuel-energy production. Precisely what that replaced option is can make a difference in the magnitude of impacts. To overcome this limitation, comprehensive modelling of climate-development impacts could be employed to determine the quantitative potential of co-benefits and trade-offs. Similarly, considering the stringency of climate measures and countries development situations in different areas helps to estimate the importance of specific impacts. Beyond interactions within a country, transboundary effects of climate and development actions must be understood to meet the SDGs globally.

We showed that some climate measures provide more co-benefits across the SDGs than others, yet, to reach global GHG-emissions neutrality before the end of the century to stay below the Paris-Agreement temperature-increase limit, action must be taken across all economic sectors. Countries will need to take early action in particular in those sectors that are more difficult to decarbonize and require extensive and costly infrastructure to avoid lock-ins and investment losses (Vogt-schilb & Hallegatte, 2017). While some flexibility exists in the selection of climate measures, this remains limited and identified development impacts will inevitably need to be tackled. For that reason, better understanding how countries could mitigate trade-offs of climate-change policies and actions and how co-benefits to the 2030 Agenda could be maximized is essential. In the following section, we discuss how the four context


Positive
Latent positive
Negative/positive
Latent negative
Negative
None identified
SDGs
Climate measures
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
14 LIFE BELOW WATER
15 LIFE ON LAND
Switch to low-carbon fuels (for electricity, heat and transport)
Solar PV
Solar CSP
Solar heating
Wind
Geothermal
Geothermal heat pumps
Hydroenergy
Biofuel/Wood biomass
Tidal/Wave
Nuclear
Fossil fuel CCS
Bioenergy CCS
Gas
Waste-to-energy & landfill
Electric vehicles

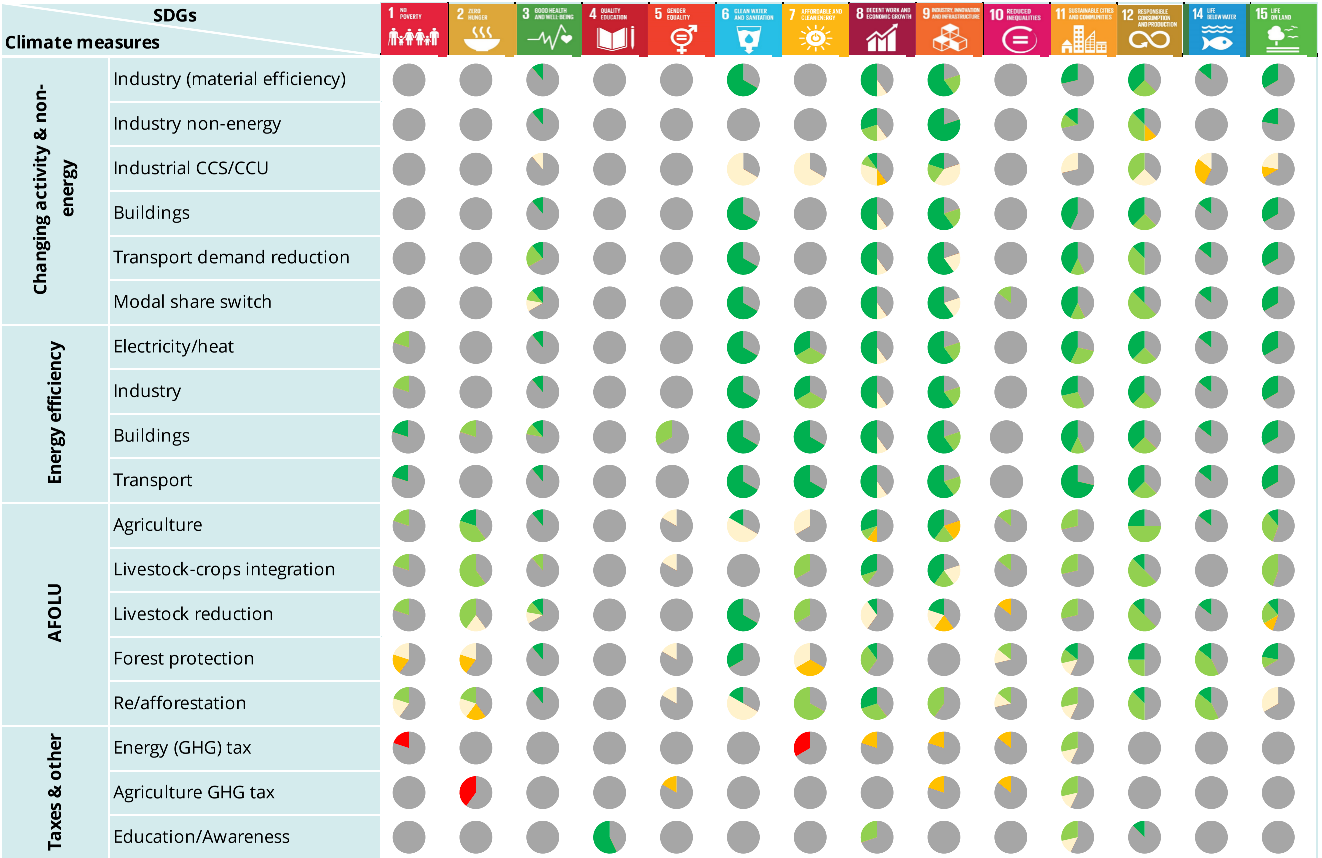


Figure 5.2 Impacts of climate-change mitigation measures on all relevant SDGs. The pie charts show the share of SDG targets that are affected, on average, in a manner described by each colour in Table 1.

dimensions can be used to address key climate-development impacts and provide a full categorization (by dimension) of the impacts identified in this section.

5.3.2 Relevance of context dimensions in addressing climate- change–SDG impacts

Our four context dimensions characterize different policy impacts and assess how they could be addressed through policy making. Adjusting the design of climate-change policies or complementing them with adequate development policies can help maximize or minimize impacts (Cameron et al., 2016, Fujimori et al., 2018, Roy et al. 2018, Nilsson et al. 2018). In the following, we discuss how each context dimension, where relevant, could be engaged to tackle climate-mitigation impacts on the assessed development areas. In this sense, we exemplify how the climate-development scoring framework is a tool to design individual policies and policy mixes through consideration of context dimensions, as defined in the 'Methods' section.

Time horizon (*when*). This dimension indicates a difference in the short- vs long-term effects. For instance, energy efficiency improvements typically require high upfront costs, but the long term savings will make energy more accessible and affordable (Ürge-Vorsatz & Tirado Herrero, 2012). Similarly, new tree plantations (afforestation or reforestation) may take up land areas that were used for food production by local communities. However, if communities are allowed access to the resulting forests, they could benefit from their timber and non-timber products and potential new activities such as ecotourism in the long run (de Jong et al., 2018; Katila et al., 2017; Roy et al., 2018).

When the time horizon dimension comes into play, it usually signals an initial higher cost before the co-benefits occur. Policy makers could adequately address the initial higher cost and protect poor households, for instance, by fully covering upfront costs, granting concessional (community) loans or enabling access to other services in the short term. Providing sustainable housing or upgrading informal housing, and providing free rooftop solar energy installations for poor households would eliminate trade-offs of upfront costs and provide multiple benefits (Winkler, 2017).

Local (geographical) (*where*). This dimension indicates a difference in impact occurrence and magnitude based on location. In that sense, it also considers situations where the overall national effect probably differs from the local effect (e.g. there could be a loss of jobs locally even if there is a net gain of jobs nationally). Typical aspects of this dimension would relate to: available local renewable energy resources (for instance, the potential of solar or wind energy); the location of potentially affected people (e.g. whether communities would lose access to land, whether they are affected by changes in air or water quality, or whether they would need to be displaced to make space for hydropower-related flooding); the location of potentially affected ecosystems (e.g. ecosystems and respective biodiversity being affected by biofuel production or afforestation); and a difference in impacts locally vs nationally (e.g. loss of jobs locally from fossil fuel phase-out but increase in jobs in the renewables sector).

When the impact depends on this context dimension, policy makers and project implementers could partly or fully avoid trade-offs or obtain co-benefits by selecting opportune locations for the implementation of measures or directly addressing local issues. For instance, while a switch from fossil-fuel electricity production to non-biomass renewables always improves air quality, countries could choose to first replace fossil-fuel power plants that affect a larger number of people. Similarly, more stringent car emissions and fuel-efficiency standards could be first imposed in cities, especially in more densely populated neighbourhoods. Trade-offs such as communities' displacement due to hydropower construction could be avoided or limited through provisions on permitted construction locations. The choice of location for marine-based energy production could signify that marine economies and their surrounding environments are affected either through co-benefits or trade-offs based on opportunities and challenges (e.g. aquaculture, shipping and transportation, tourism, other ocean resources or marine habitats protection) (McCollum et al., 2018). To ensure that livestock demand reduction leads to increased food security, the freed-up land (from livestock and feed) should be at least partly dedicated to agriculture, if feasible. Nevertheless, in some regions, such as sub-Saharan Africa, livestock might still be the most effective food source and replacing it could severely hinder livelihoods (IPCC, 2014; Roy et al., 2018).

Where trade-offs cannot be fully avoided through a choice of location, complementary local measures may need to be implemented. For instance, biofuel production can compete for land with food production resulting in higher land and food prices. Regulatory measures could define permitted areas for biofuel production where food impacts are expected to be lower. However, a lack of adequate locations probably requires complementary local interventions, such as food production subsidies and/or fixed land prices. Support for increased agricultural productivity to limit the amount of land required for biofuel and food crops locally could reduce land competition (Lotze-Campen et al., 2010). Moreover, bioenergy production can locally increase water demand and water stress, but this can be attenuated through efficient use of water, including by growing respective crops where water is more readily available (Hoogeveen et al., 2009; Taheripour et al., 2013).

Phasing out fossil fuels can result in large number of local job losses, in particular in mining areas. While a switch to renewable energy could create more jobs overall, the effect could be negative in regions with large fossil-fuel extraction industries. If most equipment is produced abroad or in a different region, the number of jobs from installations and maintenance alone may be insufficient (Samuel Fankhauser et al., 2008; Lehr et al., 2012). Hence, policies could ensure that new renewable energy jobs are created in these affected regions. To enable the transition, retraining programs for local workers (Healy & Barry, 2017; Louie & Pearce, 2016) and social protection systems for temporary unemployment may be necessary (Harrahill & Douglas, 2019; Oei et al., 2020). For instance, Altieri et al. (2016) suggest that stimulating unskilled agricultural job creation could reduce the impacts of job losses in other sectors. According to them, such an increase, which would be in line with SDG 2, could be generated through an increase in small-holder farming or through tax breaks and labour subsidies. Nevertheless, other local industries would likely also be affected by the lower incomes and likely need stimulus measures during the transition process. This could further provide additional job opportunities and prevent job losses. While locally implemented, these measures also pertain to the governance context.

Governance (*how*). This dimension indicates the relevance of the implementation approach. To address impacts that fall under this dimension, policy makers must consider the choice of technology, the choice of processes (e.g., recycling, regulations on fertilizer use) and the scope of the policy (i.e. who it applies to and how).

Multiple impacts can be addressed through a choice of more suitable technologies and practices. For instance, water demand for CCS can be reduced through system integration of processes (Brandl et al., 2017). In the energy sector, dry cooling could also reduce water demand (Fricko et al., 2016). In transport, the risk of increased exhaust inhalation and road accidents as a result of shifting to more cycling can be addressed with adequate infrastructure, such as dedicated cycle paths separated from or at a distance from roads with cars (Khreis et al., 2017). The choice of specific practices and respective technologies in agricultural and livestock production (e.g. minimum tillage, precision agriculture, inter-cropping, rainwater collection) could influence the magnitude of policy impacts (Roy et al., 2018). This is also important in the case of biofuels where multiple risks could be mitigated through clear guidelines and regulations on agricultural practices. Such measures could address nutrient leakage into the soil through limitations on fertilizer use, soil degradation through interdiction of intensive forms of agriculture, and ecosystem degradation through regulations of large-scale monocultures, in particular in vulnerable areas.

The scope of climate-mitigation measures could also play an important role in addressing policy impacts. For instance, if energy (or CO_2) taxes pose a risk of energy poverty, policy makers could waive the tax for households with lower incomes, if the tax is directly applied to consumers. Alternatively, if the energy price increase is caused by taxes applied to producers or other measures that affect energy costs, and are further passed down to consumers, an attenuation measure could be to subsidise low-income households (possibly from the tax revenue) through: direct cash transfers (Bastagli et al., 2016); tax credits, by providing a certain amount of free electricity; or free access to other services, including energy in other forms (see examples by Winkler (Winkler, 2017) on South Africa, Beck et al. (2015) and Murray et al. (2015) on British Columbia, Canada, and Combet et al. (2010) on France). Setting an upper limit for electricity prices could address price increase caused by demand, for instance, due to a higher uptake of EVs and respective demand for electricity.

Considerations of policy scope could also be used to ensure more inclusive approaches. Forest-related projects could negatively affect communities in the area if restrictions of access are introduced. However, these communities could rather benefit from the projects if inclusive measures are implemented, access is allowed and t economic activities such as pollination, are supported (de Jong et al., 2018). Forest certification programmes can be applied to ensure that social, economic and environmental benefits are enhanced and undesirable trade-offs reduced (Cerutti et al., 2014; Sikkema et al., 2014). In general, inclusive forestry projects that involve communities and support public-private-community partnerships, can support Agenda 2030 more broadly (Katila et al., 2017). In agriculture, smallholder farmers could be supported to access and benefit from new biofuel markets, for instance, by setting a limit on the maximum share of raw material that fuel producers can purchase from large agri-businesses as opposed to smallholder farmers (an example is Brazil's RenovaBio policy, but more attention is required for improved implementation and inclusion of farmers in decision making (Sakai et al., 2020)).

Climate-related measures can lead to stranded assets, such as earlier retirements of coal power plants and related infrastructure as a result of carbon taxes or strict regulations. While CCS and carbon capture and utilisation could be applied later, our results show that these approaches can generate multiple trade-offs. Moreover, not all power plants can be retrofitted in that way. Vogt-Schilb and Hallegatte (2017) provide an overview of potential governance approaches to address these impacts. For instance, policy makers could take early action to interdict the construction of such risk assets that are not zero carbon and do not comply with a 2°C global target. Alternatively, they could stimulate the inclusion of related risks in investment decisions through adequate transparency, or offer direct incentives, such as performance-based feebates and subsidies. A measure to disincentivise investments could be the progressive phase-in of carbon pricing, starting with lower prices to limit potential stranding of current assets. Carbon taxes and cap-and-trade systems can be designed in a way that compensate owners of polluting assets through partial exemptions, rebates and grandfathered emissions allowances. In the case of assets that are already in place, countries might find themselves constrained to directly compensate owners of stranded assets in some form, for instance, through direct public procurement from owners. The impacts of stranded assets are particularly important in countries that are highly invested in fossil fuels, including through mining of domestic fossil fuel resources. Hence, these measures are also relevant to policy impacts that are affected by the 'natural resources' dimension discussed below.

Natural resources (i.e. limited fuels) (*what*). We introduced this dimension to cater for impacts that depend on the availability of limited natural resources nationally rather than locally. For instance, countries that depend on imports of energy resources such as nuclear or fossil fuels, are prone to energy-security issues resulting from price volatility and potential trade obstacles. These issues could be exacerbated by an increased demand for these fuels or reduced by a switch to other energy sources. On the other hand, countries that are producers (and potentially exporters) of such fuels, could be more affected by job and revenue losses as a result of measures to phase out these fuels. Exporting countries are also prone to price volatility and demand on the international market.

To mitigate trade-offs linked to the availability of limited natural resources, countries with specific contexts may choose to avoid policies that increase the demand for these fuels and support policies that reduce dependency. Where investments have already been made in the exploitation and use of these limited resources, countries could apply aforementioned measures to limit the impacts of stranded assets and of job and economic losses. While governments could support private owners of stranded assets in various ways (see previous section), the national economic effects would also need to be addressed. Internationally, support supply-based treaties and the possibility to trade the rights to exploit fossil fuel reserves could be in the interest of fossil-fuel rich countries. This allows others to buy and not burn them (Asheim et al., 2019; Harstad, 2012). Finally, although we have not assessed fossil-fuel-subsidies removal as a climate measure, their economic, political and overall effects would be very similar to that of energy (CO_2) taxes and could be addressed in a similar manner (Vogt-schilb & Hallegatte, 2017).

5.3.3 Prominence of context dimensions across climate-change–SDG impacts

We found that the vast majority of climate-mitigation impacts on the SDGs are dependent on the governance (73% of all identified impacts) and the local context (71%) dimensions. The time horizon and natural resources contexts only cover approximately 12% of climate-mitigation impacts each in their area of influence (Figure 5.3).

Unsurprisingly, the local context is particularly important for the environmental SDGs (i.e. SDGs 6 (water and sanitation), 14 (life under water) and 15 (life on land)) as the impacts of climate-mitigation projects can be bigger in areas closer to important ecosystems. Moreover, as local communities often depend on access to ecosystems to ensure their livelihoods, and as some climate measures affect specific (fossil fuel rich) regions more strongly than others, where climate measures are implemented, is also particularly important for SDGs 5 (gender equality) and 10 (reducing inequalities). Finally, the local context is important for health. In this case, the number of people who would be positively or negatively affected depends on the density of population in the area of influence of the climate-mitigation measure.

The governance context is particularly important for SDGs 5, 8 (in particular for the employment dimension) and 10, as the governance approach can enhance inclusiveness of relevant groups of stakeholders to benefit from co-benefits and can reduce trade-offs on vulnerable groups. In part, this can also be done through measures that enhance education and training, and raise awareness. These are key targets of SDG 4 (training and education). As the choice of infrastructure, technology and processes are key to the achievement of targets under SDGs 2 (agriculture and food security), 9 (industry and infrastructure) and 12 (sustainable production and consumption), the governance context is also prominent in these areas.

The time horizon is especially relevant for SDG 1 (poverty reduction) and SDG 7 (energy) due to the high upfront costs of renewable energy and energy efficiency improvements. While the installation costs of renewables are still very high, the levelized cost of electricity production (i.e. total costs of energy production, including installation, over longer time periods) is now comparable to and in some places even lower than that of fossil fuel electricity production (NEA, 2018; Ouyang & Lin, 2014). Moreover, despite the high upfront costs, energy efficiency improvements lead to financial savings in the long run. The time horizon is also highly relevant for SDG 8 (economic growth and jobs). Although phasing out fossil fuels could have some trade-offs on economic growth through higher energy prices and a decrease in revenue from fossil fuel exports, it helps decouple countries from dependence

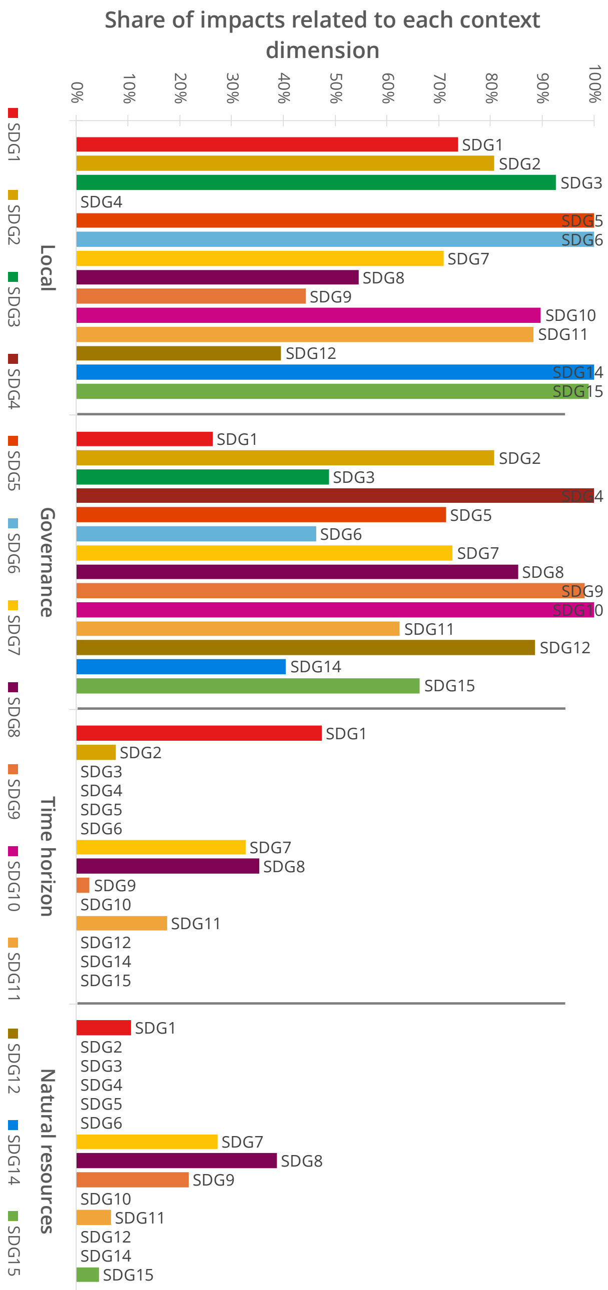


Figure 5.3 Share of climate-change-mitigation policy impacts per SDG, relevant to each of the four context dimensions - local, governance, time horizon and natural resources. The share of impacts is determined as the total number of identified climate-change-mitigation policy impacts on an SDG, relevant to one context dimension, relative to all identified climate-change-mitigation policy impacts on that SDG (regardless of context dimensions).

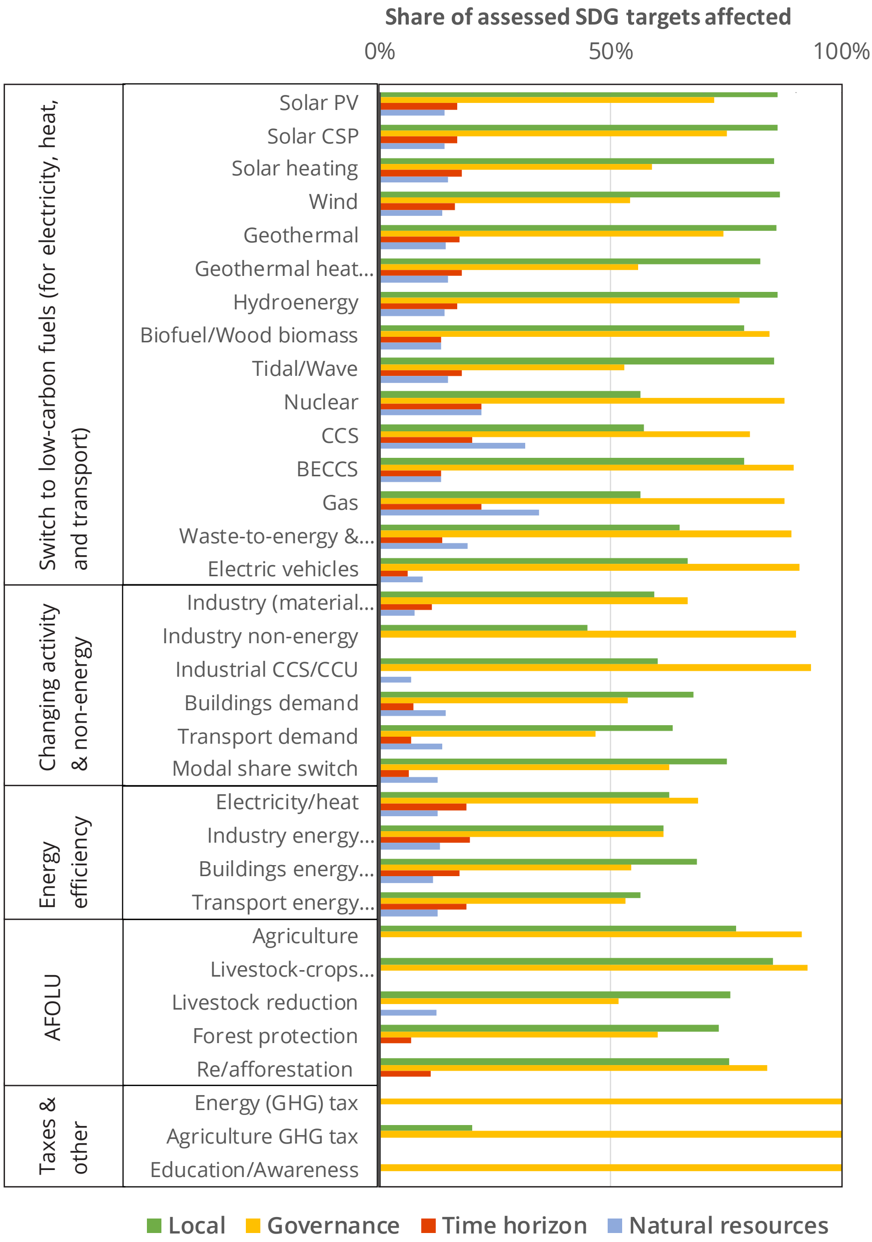


Figure 5.4 Share of SDG impacts of each climate-change mitigation measure that fall under the four specific context dimensions – local, governance, time horizon and natural resources. The share of impacts is determined as the total share of impacts of a specific climate-mitigation measure across all SDG targets that are relevant to a context dimension relative to the total number of impacts of that specific climate-mitigation measures.

on limited resources and potential stranded assets in the long run. On the other hand, renewable energy generation creates a large number of jobs for installation, but requires very few jobs for operation. In that sense, producing renewable energy equipment could help create more jobs.

The availability of limited natural resources for energy production (i.e. nuclear and fossil fuels) determines the magnitude and the direction of the impacts of a switch away from or towards these resources on economic growth and jobs (i.e. SDG 8). Moreover, a switch away from these limited natural resources in countries with strong respective industries could lead to non-inclusive industrialization, especially if these industries cannot easily transition (e.g. fossil fuel energy producers switching to renewables) – against the target of SDG 9.

In terms of climate-change mitigation measures, the local context and governance dimensions are highly relevant to most measures (Figure 5.4). However, while governance is not only important to energy (CO_2) and agricultural taxes, but also for training, education and awareness raising, the local context does not play a role in these measures. On the other hand, the local context is particularly important for renewable energy measures as the amount of energy produced is determined by local renewable energy resources. Moreover, economic and employment impacts of a fossil fuel phase-out are particularly relevant locally in regions of fossil fuel production. Due to aforementioned effects, time horizon and natural resources are mainly relevant to climate-change-mitigation measures that address energy demand and energy source choice.

While our study comprehensively captures the relevant context dimensions for all climate-change mitigation impacts on the SDGs, the importance of each dimension may vary across countries. Therefore, the relevance of each impact and of respective context dimensions on a country-by-country basis must essentially be studied in detail. Moreover, while here we provided several examples of potential policy designs and policy mixes to enhance co-benefits and minimize trade-offs based on the context dimensions, the governance mode and other contextual aspects within a country could make specific types of policies more appealing than others (e.g. regulatory vs market measures). Measures that address climate-change mitigation impacts would need to be tailored to the country's context. From a research perspective, a wide variety of possible policy designs and policy mixes must be identified to highlight best practices for specific country contexts.

The extended range of policy impacts shows that ensuring policy coherence and adequate communication horizontally, across relevant sectors, and vertically, across relevant actors is essential. To that end, our scoring framework of climate-change mitigation impacts on the SDGs becomes a tool for enhanced dialogue between policy makers and relevant actors across governance levels and sectors. Researchers from different academic fields could also engage in such a dialogue. From a research perspective, our results could, for instance, be integrated in models that seek to identify sustainable development pathways to meet multiple SDGs. Moreover, our scoring framework could be used for national broad or detailed case studies on climate- change—SDG interactions with a focus on specific development areas or SDGs.

Beyond the country level, our approach could also be applied in international negotiations and development cooperation. A good understanding of the interlinkages between climate-change action and other SDGs can help to better integrate international climate governance with other strands of international negotiations, such as trade and environmental agreements (Azizi et al., 2019; Brandi et al., 2019; Dombrowsky & Hensengerth, 2018; Rantala et al., 2020; UN, 2018). Such integration is essential to ensure policy coherence and jointly implementing Agenda 2030. Moreover, a better understanding of climate-development interactions is key to effective development cooperation. As every additional global temperature increase can hinder development (Hoegh-Guldberg et al., 2018), development actors should be captivated to address climate change. Additionally, development actors also should be able to assess the risk of stranded assets and the benefits and potential trade-offs of climate-relevant projects. Ensuring that climate-change strategies and development strategies are designed and implemented in a coherent manner can increase the efficiency and effectiveness of development cooperation and respective finance, as discussed in Chapter 4.

Although we carried out a thorough literature review for the interlinkages between climate-change mitigation and other development areas, assuming that some climate- change—SDG interlinkages are still missing in our analysis, is reasonable. We possibly have missed some literature and evidence of some interlinkages maybe has not yet been published. Moreover, although we covered the key context dimensions, other dimensions can be important in specific countries and along with them, their country-specific policy impacts. Hence, the absence of impacts in our scoring framework should not be automatically assumed to be robust. Nevertheless, our analysis is highly comprehensive and represents an important basis for country-level assessments.

5.3.4 Choice of climate-change mitigation measures in the G20 member states

We hypothesize that countries are likely to give a higher priority to climate-change mitigation measures that result in most co-benefits. Even if all types of climate-mitigation measures eventually need to be adopted to meet the Paris Agreement temperature goal, instantly adopting measures that are characterized by co-benefits, likely yields more benefits in the long term. To test this hypothesis on national climate-change policy preferences, we used the Climate Policy Database (as per the last update of Nascimento et al. (under review)) to map climate-change-related policies and measures in the G20 countries.

We found that climate-change mitigation policies that had a higher overall cumulative impact score (see Footnote 45; i.e., that have more co-benefits and fewer trade-offs), are adopted by most or all G20 countries (Figure 5.5). Moreover, these highly beneficial policies are also prioritised within countries, being more frequently adopted relative to other relevant policies in each country. These findings demonstrate that climate-change mitigation policies with more co-benefits are, indeed, more often adopted. These policies are particularly related to energy efficiency improvements, renewables (whereby we used the average cumulative score across all renewable sources to address a lack of differentiation in the policy database) and agriculture and forestry. The relatively lower adoption levels of policies and measures that reduce demand for energy and material through structural changes (i.e. changing activities) despite their high cumulative impact scores, appear to reject our hypothesis. However, these measures are most often adopted at a city level (e.g., measures for compact cities) and do, therefore, not focus on national legislative and executive bodies. Furthermore, while climate-change-related policies and measures with substantial development co-benefits are universally attractive, each country has different development priorities and therefore probably benefits more from some types of policies than others.

While our analysis shows that climate-change mitigation measures with more co-benefits tend to be adopted by more G20 countries, it does not provide any information about the real motivation behind policy adoption nor about the policy stringency or the magnitude of actual impacts. Moreover, we correct for country differences in national policy-type adoption levels and aggregation approaches by comparing policy numbers relative to one another in the same country. However, some policy measures generally have a higher level of aggregation than others. For instance, multiple types of measures and incentives can be implemented to support renewables, energy efficiency and most other policies. Yet taxes are a measure in themselves. This was corrected by assessing shares of countries that adopted the policies, but this would not be accurately expressed when assessing the share of policies of each type relative to each other. For a more in-depth understanding of national climate-development policy coherence, the objectives, the ambition levels (i.e., stringency) and the real effects of policy implementation should also be analysed. As (G20) countries must ramp up their climate-mitigation ambition (Roelfsema et al., 2020), understanding climate-change—SDG interlinkages and addressing major context dimensions are essential to enable the needed ambition and a joint implementation of the Paris Agreement and the 2030 Agenda.

5.4 Conclusions

Substantial efforts are needed at all policy levels to meet Agenda 2030's SDGs and to ensure that global temperature increase stays well below 2°C. While these targets were set independently, strong climate-development interconnections suggest that they should be addressed in conjunction rather than in their climate-change or development silos.

We built a comprehensive overview of climate-change mitigation policies impacts on all SDG targets. We found that climate-change mitigation directly affects 15 out of 17 SDGs. This advocates a high potential success when climate and development issues are simultaneously tackled. Climate-mitigation policy types with many co-benefits are energy efficiency and energy-services demand reduction. When compared to fossil fuels, most renewable energy sources also have multiple co-benefits to sustainable development. The policy areas that appear to have most trade-offs with the SDGs, are nuclear, CCS, followed by biofuels, natural gas and energy (CO_2) and agriculture taxes. Among the SDGs, the environmental and economic SDG targets much better cover policy impacts than the social targets.

Most importantly, our study heeded previous calls to go beyond simple identification and scoring of climate-change mitigation impacts (Nilsson et al., 2016) and elucidated how these impacts relate to four key context dimensions (i.e. geographical, governance, time horizon and natural resources). Moreover, we highlighted how an understanding of the impacts context dimensions facilitates policy design and policy instruments that can directly tackle policy impacts, minimize trade-offs and maximize co-benefits. We found that the governance approach and location choice are particularly important as they are relevant to most identified climate-change—SDG impacts.

Number of policies in each country		Argentina	Australia	Brazil	Canada	China	European Union	India	Indonesia	Japan	Republic of Korea	Mexico	Russian Federation	Saudi Arabia	South Africa	Turkey	United States of America	Perccentage countries	Average level of focus	Total impacts score
Switch to low-carbon energy sources	Renewables	12	12	12	7	42	18	20	22	20	27	25	12	8	13	14	31	100%	13%	35
	Nuclear	2	0	0	3	3	0	0	1	3	3	0	3	1	2	0	5	63%	1%	2
	CCS	0	1	0	2	0	4	1	0	1	4	1	0	0	0	0	7	50%	1%	-17
	Gas	0	2	3	5	3	5	2	1	5	1	1	5	1	3	2	10	94%	2%	0
	Electric vehicles	1	2	3	4	6	3	5	3	7	8	5	2	0	1	2	2	94%	2%	11
Changing activity & non-energy	Industry non-energy	1	6	5	10	8	16	6	2	7	6	6	6	3	7	2	8	100%	5%	22
	Industry (material efficiency)	2	5	2	6	14	11	3	2	7	6	3	4	2	8	2	3	100%	4%	35
	Buildings	1	4	1	4	7	4	5	1	8	5	3	2	1	3	4	4	100%	2%	38
	Transport	2	3	3	3	8	7	5	1	12	9	5	1	4	10	3	12	100%	4%	35
	Modal share switch	5	3	7	9	10	14	7	7	12	16	9	5	2	8	6	26	100%	6%	37
Energy efficiency	Electricity/heat	4	5	9	6	12	11	4	5	15	23	7	10	5	9	8	33	100%	7%	42
	Industry	5	12	10	12	28	15	8	10	18	13	8	6	5	11	12	15	100%	8%	40
	Buildings	8	21	9	18	20	17	24	10	32	18	28	15	6	14	17	33	100%	13%	47
	Transport	6	15	9	15	16	17	12	8	25	15	10	2	4	8	9	28	100%	8%	44
AFOLU	Agriculture	12	4	13	9	12	5	15	9	9	8	10	2	5	8	13	18	100%	7%	23
	Forestry	14	5	21	12	23	10	24	29	12	9	13	4	5	9	17	18	100%	11%	19
Taxes & Other	Energy (GHG) tax	1	0	1	1	2	1	2	0	3	2	3	1	1	4	1	0	81%	1%	-5
	Agriculture GHG tax	1	0	1	2	1	0	1	0	0	2	2	1	1	3	0	0	63%	1%	-7
	Education/Awareness	4	8	2	4	2	3	3	0	2	5	2	1	1	3	3	41	94%	3%	4

Figure 5.5 Current climate-change-mitigation relevant policies in G20 countries (Source: Climate Policy Database, updated by Nascimento et al. in review). The first twenty columns show the number of specific types of climate-change mitigation policies in each country. The column 'Percentage countries' shows the share of G20 countries with policies of a given type. `Average level of focus` shows the average share of a given policy type in the total number of measures per country. `Total impacts score` shows the sum of these policies impacts on SDG target, as presented in Figure 5.2, but using average across technologies for renewables. Numbers are shown from red (low value) to green (high value) based on values relative to each other along the columns.

Our scoring framework and related analysis developed is especially of interest to policymakers as it helps prioritize climate-action areas of substantial co-benefits and areas where trade-offs must be considered. In this sense, policy makers can use our framework to identify ways to ratchet up climate ambitions, while also efficiently meeting the SDGs. While some climate-change mitigation measures have more co-benefits to sustainable development than others, meeting the international climate targets require countries to take climate-change mitigation actions across all economic sectors. Smart policy designs that consider co-benefits and trade-offs, are essential to facilitate ambitious and effective strategies that jointly implement the Paris Agreement and the 2030 Agenda nationally and internationally. Internationally, countries could consider including climate-change—SDG interactions in their Voluntary National Reports under Agenda2030, and their NDCs under the Paris Agreement. This likely not only encourages communication between relevant governmental ministries but also enhances policy coherence. The scoring framework could also be applied to facilitate dialogue and enhance coherence nationally and internationally, and between climate and other governance fields.

We found that climate-change mitigation measures that entail higher development benefits, are adopted more often in the G20 member states. This suggests that countries seek to capitalize on the co-benefits of climate-change mitigation, but are reluctant to adopt measures that spawn trade-offs with other development areas. While these results are not surprising, they highlight the challenges of ambitious climate-change action and the need for further support to tackle stated challenges. To meet the longer-term goal of net GHG neutrality, all sectors need to reduce GHG emissions. Early action limits lock-in effects and creates flexibility (Swart et al., 1998), and stops social and environmental trade-offs of fossil fuels.

Our study aimed to advance the knowledge of climate-development synergies and trade-offs that would simultaneously address climate and sustainable development goals. Nevertheless, our scoring framework is surely also applicable to other SDG-action areas to further map interactions among the SDGs, to identify other relevant context dimensions and enhance policy coherence across the SDGs.

Increased ocean temperatures lead to rapid coral bleaching and decay.
Photo taken in Queensland, Australia, 2012

Climate change affects natural habitats and threatens biodiversity.
Photo taken in Eduardo Avaroa National Park, Bolivia, 2014.

6

Gaps and opportunities for synergies in international environmental law on climate and biodiversity to promote the Sustainable Development Goals

This chapter is based on:

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6.1 Introduction

The Sustainable Development Goals (SDGs) represent a new mode of governance through shared goals instead of legally binding international agreements (Biermann et al., 2017). Nevertheless, global action is required as the sustainability challenges transcend national boundaries. This is particularly true for global environmental commons that make up the stock of global natural capital and sustain life on Earth. International law recognizes four specific areas of global commons that fall outside of any national jurisdiction: the high seas, the atmosphere, Antarctica and outer space. In the context of sustainable development, other commons which may lie within national or regional jurisdictions, but whose continuing existence confers benefits beyond them, are often mentioned: the tropical rain forests, land and biodiversity (IGS, 2019).

Although the environmental dimension has been deemed as the main priority for ensuring sustainable development in the long run (Griggs et al., 2013), the global environmental commons are currently deteriorating at an unprecedented rate, and the impacts are felt across borders (IGS, 2019) – unevenly across the world (UN Environment, 2019). Moreover, SDG 13 (climate action), 14 (life under water) and 15 (life on land) are expected to be further affected by progress on the socio-economic SDGs in a business-as-usual scenario (Randers et al., 2019). The required action to reverse the negative trends also includes cooperation through appropriate international legal frameworks (Blicharska et al., 2019; UN, 2018).

The global environmental commons are intrinsically linked. For instance, biodiversity is affected by climate change, with negative consequences for human well-being. At the same time, biodiversity, through the multiple ecosystem services it supports, also makes important contributions to both climate-change mitigation and adaptation (Blicharska et al., 2019; Secretariat of the Convention on Biological Diversity, 2019). Consequently, conserving and sustainably managing biodiversity is critical for addressing climate change, and vice versa. In order to harness the synergies and achieve cost-effective action in safeguarding the global commons and to reverse their deterioration, these interactions need to be better understood and accounted for in actions spanning multiple scales.

In general, it has been argued that achieving the SDGs requires knowledge about the interactions between different SDGs (i.e. how action to promote a specific goal or target supports or hinders the achievement of the other goals). Previous analysis has identified both trade-offs as well as synergies between efforts that intend to promote different goals (ICSU, 2017; IGS, 2019; Nilsson et al., 2016). Though the SDGs are grounded in existing commitments expressed in various international agreements and soft law instruments (Kim, 2016), there is scarce explicit empirical analysis of how the interactions between different SDGs are addressed by the international legal framework, particularly international environmental law (IEL) (but see: Ntona and Morgera, 2018; Azizi, Biermann and Kim, 2019a). Most international institutional arrangements tend to operate in relative isolation, and the potential of the SDGs, as 'integrated and indivisible', to introduce coherence remains an open question (Kim, 2016). At the same time, international law provides a normative context in which the SDGs and targets should operate and interact with each other – and hence the fragmented structure of IEL (UN, 2018) is likely to affect the trade-offs and synergies between various SDGs (Kim, 2016).

In this paper, we focus on the interactions between climate action (SDG 13) and halting (terrestrial) biodiversity loss (SDG 15) vis-à-vis the international legal framework; in particular, the relevant major legal instruments: the United Nations Framework Convention on Climate Change (UNFCCC)[44] and the Convention on Biological Diversity (CBD).[45] First, we review the drivers of climate change and biodiversity loss and identify actions that would likely harness synergies in efforts to promote SDGs 13 and 15 based on existing literature (Section 2). An analytical framework, including a set of focus areas and related keywords, is derived from the review. The UNFCCC and CBD are then analysed for their potential to support harnessing those synergies, as well as the extent to which they address potential trade-offs between SDGs 13 and 15 (Section 3). Our focus is on the global goals at the level of their main intent (i.e. halting biodiversity loss and climate change), although we also make some reference to interactions at the level of specific targets under the SDGs.

The UNFCCC and the CBD are two of the conventions that opened for signatures at the Rio 'Earth Summit' in 1992. The CBD is the main international legal instrument addressing the conservation and sustainable use of biodiversity (UN, 2018), ratified today by 196 parties. The three overarching objectives of the Convention are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of benefits from the utilization of genetic resources (CBD, Article 1). The UNFCCC also has nearly universal membership, ratified today by 197 parties. Its ultimate objective is the stabilization of greenhouse gas concentrations in the atmosphere 'at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system' (UNFCCC, Article 2). Together with

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44 United Nations Framework Convention on Climate Change, New York, 9 May 1992, in force 21 March 1994, 31 International Legal Materials (1992) 849, <http://unfccc.int>.

45 Convention on Biological Diversity, Rio de Janeiro, 5 June 1992, in force 29 December 1993, 31 International Legal Materials (1992) 822, <http://www.biodiv.org>.

the third Rio Convention, the Convention to Combat Desertification (CCD),[46] these Conventions are intrinsically linked at the outset. A Joint Liaison Group is to boost cooperation among the three Conventions and to develop synergies in their activities on issues of mutual concern.[47]

Here, we analyse how those synergies are reflected in the CBD convention text, Conference of Parties (COP) decisions, primarily those adopted after 2015 (the starting year of the Agenda 2030 and the SDGs), the Strategic Plan 2011-2020 and its Aichi targets,[48] as well as the Zero Draft of the new post-2020 Global Biodiversity Framework[49] published in January 2020. These documents reflect the most current status of the ongoing discussion on how to address drivers, potential trade-offs and co-benefits between SDGs 13 and 15 and how to promote synergies under the CBD. COP decisions on biodiversity and climate change that have been adopted before 2015 were taken into account additionally. Key UNFCCC agreements and relevant COP decisions were analysed in parallel. The focus was on a large set of COP decisions that addressed land use, land-use change and forestry, including the most recent decisions on agriculture. Additionally, decisions taken at the last two Climate COPs in Katowice (December 2018) and Madrid (December 2019), including those serving as the meetings of the Parties under the Kyoto Protoco[50] and under the Paris Agreement,[51] were assessed. The overarching UNFCCC agreements included were the Convention itself, the Kyoto Protocol, the Copenhagen Accord[52] and the Paris Agreement.

Concurrently, we analyse how the interactions between SDGs 13 and 15 are addressed in the context of the United Nations Environment Assembly (UNEA) in Section 4. UNEA was created at the United Nations Conference on Sustainable Development ('Rio+20') in 2012, when world leaders called for United Nations Environment Programme (UNEP) to be strengthened and upgraded.[53] It is considered

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46 United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and or Desertification, Particularly in Africa, Paris, 17 June 1994, in force 26 December 1996, 33 International Legal Materials (1994) 1309, <http://www.unccd.int>.

47 UNFCCC, 'The Joint Liaison Group', available at <https://unfccc.int/about-us/about-the-secretariat/the-joint-liaison-group> (visited 29 April 2020).

48 'The Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets', CBD Dec. 10/2 (2011).

49 CBD, WG2020-02 documents, available at <https://www.cbd.int/conferences/post2020/wg2020-02/documents> (visited 20 April 2020).

50 Kyoto Protocol to the United Nations Framework Convention on Climate Change, Kyoto, 11 December 1997, in force 16 February 2005, 37 International Legal Materials (1998) 22.

51 Paris Agreement to the United Nations Framework Convention on Climate Change, Paris, 12 December 2015, in force 4 November 2016; 55 International Legal Materials (2016) 740.

52 'Copenhagen Accord', UNFCCC Dec. 2/CP.15 (2009).

53 'The future we want', UNGA Res. 66/288 of 27 July 2012, para. 88.

to be the world's highest-level decision-making body on the environment, with the specific role in setting the global environmental agenda and providing overarching policy guidance and defining policy responses to address emerging environmental challenges.[54] Though UNEA outcomes – resolutions, decisions and Ministerial declarations – are not international legal instruments, they constitute the outcome of a global political process which is part of the institutional architecture for international environmental governance. This consists of a decentralized web of multilateral institutions, agreements, processes and consultative mechanisms that address environmental and environment-related matters within the broader context of sustainable development.[55] Consequently, UNEA outcomes can be considered a complementary source of guidance within the international environmental policy context. In particular, UNEA outcomes influence UNEP which is responsible for supporting governments to develop and implement multilateral environmental agreements (MEAs), fostering collaboration between different intergovernmental environmental institutions, and supporting the science-policy interface.

The outcome documents of the past four UNEA sessions are analysed in a chronological order to understand the evolution of attention to drivers and SDG interactions in the international discussion, since UNEA-1 held in June 2014 until UNEA-4 held in March 2019 (UNEA-2 and UNEA-3 were held respectively in May 2016 and December 2017).

A list of all analysed CBD, UNFCCC and UNEA documents can be found in the Supplementary Material of this chapter.

In the following sections of this paper, we thus address the questions:

1. What are the drivers behind climate change and biodiversity loss, and what kind of actions would be likely to create co-benefits for SDGs 13 and 15?

2. How do the key international legal instruments, UNFCCC and CBD, currently address the common drivers of climate change and biodiversity loss? Can potential to support co-benefits for climate and biodiversity action be identified, and how are potential trade-offs between advancing the two goals addressed? Which synergetic aspects are currently not addressed in these instruments?

3. How are interactions between SDGs 13 and 15 addressed in the outcome documents of UNEA? Do they emphasize new or different aspects with regard to interactions, compared to the CBD and UNFCCC?

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54 'Delivering on the 2030 Agenda for Sustainable Development', UNEA Res. 2/5 (2016).

55 'Relationship between the United Nations Environment Programme and multilateral environmental agreements', UNEA Doc. UNEP/EA.1/INF/8 (2014).

6.2 Understanding interactions: drivers of climate change and biodiversity loss

Though climate and biodiversity are interlinked in numerous ways, we focus on a particular angle of investigation that allows us to explore synergies and trade-offs between SDGs 13 and 15 in IEL: the fundamental drivers that contribute to both climate change and terrestrial biodiversity loss at the global level. These drivers are increasingly well-understood and, despite being complex and interlinked, there is considerable scientific consensus on them (IPBES, 2019; Oreskes, 2018). Likewise, there is mounting evidence of the type of actions with potential to produce co-benefits for climate efforts and biodiversity conservation (see, for instance, Bryan et al., 2016; Deng et al., 2017; Dybala et al., 2019).

Biological diversity comprises genetic, species and ecosystem diversity (CBD, Article 2), underpinning the functioning of ecological systems and human well-being. There is scientific consensus that globally, biodiversity is being lost at an unprecedented rate (IPBES, 2019), and the five targets of SDG 15 with a timeline to 2020 (15.1, 15.2, 15.5, 15.8 and 15.9; see below) have mostly seen little or insufficient progress, making them likely to be missed (UN, 2020). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has identified the direct drivers with the largest global impact on biodiversity (starting with those with most impact): changes in land and sea use (causing habitat change, loss and degradation; UNEP, 2019b); direct exploitation of organisms; climate change; pollution; and invasion of alien species (IPBES, 2019).

Those direct drivers result from an array of underlying, indirect drivers that include production and consumption patterns, human population dynamics and trends, trade, technological innovations and local through global governance. Agricultural expansion has had the most significant effect on land-use change, along with rapid urbanization and expansion of infrastructure, linked to growing population and consumption. These dynamics support the notion that SDG interactions need to be accounted for to make progress on or to achieve the SDGs. Climate change is a direct driver of biodiversity loss, linked to many of the same underlying drivers mentioned above and compounding the effects of the other drivers (IPBES, 2019). Hence, the drivers of biodiversity loss are complex, multiple and interlinked. Many of the threats, as well as the habitats, ecosystems or species to which they apply, do not respect national boundaries or are found in areas beyond national jurisdiction (UN, 2018). For instance, international trade and consumption in developed countries drive biodiversity threats in developing countries (Lenzen et al., 2012).

Climate change is among the most important drivers of biodiversity loss. Thus, addressing the drivers of climate change will have indirect benefits for biodiversity – as long as the actions chosen to mitigate climate change do not imply trade-offs for biodiversity. Climate change is caused by anthropogenic greenhouse gas (GHG) emissions resulting from a similarly complex web of interacting drivers (Blanco et al., 2014), including fossil-fuel combustion related to energy, industry and transportation as well as land use, land-use change, agriculture and forestry (addressed under SDGs 7, 9, 2 and 15, respectively, but also influenced by other SDGs). These, in turn, are driven by economic and population growth, consumption and international trade (addressed in particular under SDGs 8, 12 and 17; Blanco et al., 2014; UNEP, 2019b). There is great regional variation in the GHG emission patterns. A considerable share of emissions in developing countries is released in the production of goods and services exported to developed countries (ibid.).

An estimated 23 per cent of the total anthropogenic GHG emissions (2007-2016) derive from Agriculture, Forestry and Other Land Use (AFOLU). These net emissions are mostly due to deforestation, partly offset by afforestation/reforestation, and emissions and removals by other land use activities. Also changes in land conditions – such as degradation of soils, forests and peatlands as well as desertification – contribute to climate change (Masson-Delmotte et al., 2020). Management of land and forests is particularly important as degradation and deforestation contribute to carbon sources, whereas when well-managed, they function as carbon sinks (see, for instance, Qie et al., 2017; Mitchard, 2018).

Thus, land use change and degradation contribute to both biodiversity loss and climate change, linked to many of the same interacting drivers. Land use change due to agricultural expansion is projected to increase, driven by population and income growth and changes in consumption patterns (Masson-Delmotte et al., 2020). Conversely, addressing the drivers of land use change and land degradation has potential to create co-benefits for climate action and halting biodiversity loss.

The Intergovernmental Panel on Climate Change (IPCC) has estimated synergies and trade-offs of climate change mitigation options for different SDGs. Mitigation options that target energy supply with bioenergy and large-scale hydropower (also contributing to SDG 7 on energy) may have trade-offs with SDG 15 due to increased demand for land for bioenergy crops and for dam construction. Those targeting energy demand (behavioural responses, energy efficiency etc.) and land-based mechanisms are largely characterized by synergies (Allen et al., 2018, p. 20 Figure SPM.4). Such land-based options include limiting the demand for land through sustainable intensification of land-use practices, soil carbon sequestration, livestock and manure management, reduced deforestation, afforestation and reforestation, sustainable forest management, ecosystem and land restoration and changes towards less resource-intensive diets and reduced food waste (Allen et al., 2018; Masson-Delmotte et al., 2020).

In particular, conservation, restoration, sustainable management and use of forests is often emphasized when seeking co-benefits for the climate and biodiversity, as well as for other SDGs (Katila et al., 2019). Reducing Emissions from Deforestation and Forest Degradation (REDD+), a mechanism developed by Parties to the UNFC-CCC, seeks to mitigate climate change through results-based payments for carbon storage and enhancement from halting forest area loss and forest degradation, with incremental co-benefits for biodiversity and sustainable development. A large body of academic literature on the biodiversity co-benefits of climate change mitigation efforts focuses on the potential of REDD+ to deliver them (Deng et al., 2017). Yet, the co-benefits are not automatic but context-specific, depending on how the actions are carried out (Allen et al., 2018; de Jong et al., 2019). For instance, the impacts on biodiversity of large increases in forest cover would depend on the nature of the land affected, how it is afforested, and the tree species involved. It might also have negative impacts on biodiversity by displacing other land uses, with potential knock-on effects for a range of SDGs (Blicharska et al., 2019).

Kroll et al have found that the associations between SDGs 13 and 15 have strengthened in recent years (2017-2018), showing both clear trade-offs and synergies, but synergies are expected to increase slightly by 2030 (Kroll et al., 2019). Three key targets of SDG 15 are directly linked to climate action: 15.1 on freshwater ecosystems, including forests and wetlands (which act as carbon sinks and could turn into carbon sources when degraded); 15.2 on sustainable forest management and halting net deforestation; and 15.3 on soil protection and restoration (which will support carbon storage in soil and ensure sufficient land for agriculture and biofuel production). Moreover, four other targets of SDG 15 can be affected by or support climate action under specific circumstances: 15.4 on mountain ecosystems (which will be affected by climate change, with particularly strong impacts on glacier ecosystems); 15.5 on protection of natural habitats (which will contribute to maintaining carbon sinks and may be affected by climate change); 15.8 on invasive species (whereby biofuel and forest plantations can introduce non-native species); and 15.9 on integrating ecosystem and biodiversity values into national and local planning (which will also lead to protection of carbon sinks). All these targets are also linked to climate adaptation as the protection, restoration and appropriate management of ecosystems will ensure resilience and will be much needed actions to adapt to climate change impacts. As the targets of SDG 13 are broadly defined around climate action for both adaptation and mitigation in fairly general terms, all of them are expected to interact with the aforementioned targets of SDG 15. This further justifies an approach that pays attention to the interactions primarily at the level of the goals instead of individual target interactions.

In sum, various land-based actions have potential to create synergies for climate action and halting biodiversity loss. However, the actual mechanisms need to be tailored to local conditions to attain co-benefits and to avoid trade-offs, and they need to be adaptive (IGS, 2019). At the same time, it is acknowledged that governing land requires approaches that better manage globalized flows of land-based resources and address power asymmetries between actors across scales and locations (ibid.).

We also anticipate that international regulation that addresses the underlying drivers, such as global trade flows, production and consumption patterns (targeted by SDG 12), especially in developed and emerging economies, is highly relevant. Institutional and governance factors, such as policy coherence (SDG target 17.14), capacity-building (SDG target 17.9), promoting cross-sectoral and cross-jurisdictional integration and mainstreaming, adaptive management and strengthening the implementation of environmental laws and policies at various scales, are widely recognized to be crucial (ibid.; IPBES, 2019b; UNEP, 2019b).

The following analysis of CBD, UNFCCC and UNEA is based on a thorough reading of the relevant documents, guided by the research questions and an analytical framework based on the above identified drivers and synergy-enhancing actions. This framework includes fossil fuels, climate change and land use change as direct drivers. These drivers will be particularly influenced in the future by the approach and extent of implementation of SDGs 2, 7, 13 and 15. Moreover, the framework includes indirect drivers, namely demographic and socio-cultural, economic and technological, and governance, corresponding to the IPBES categorization of indirect drivers (IGS, 2019; IPBES, 2019; UN Environment, 2019). These indirect drivers are expected to change in the future as a result of the implementation (or lack thereof) of the SDGs at large. We complemented the direct and indirect drivers in the analytical framework with keywords on key areas of intervention that allow for synergies or easily imply trade-offs: 1) agriculture, food security, food production and consumption (related to SDG 2); 2) biodiversity, ecosystems, environment and forests (most closely associated with SDG 15); 3) sustainable consumption and production (SDG 12); and 4) policy coherence[56]. Finally, the nature of the legal language used in

56 Policy coherence was considered as particularly important for its potential to enhance synergies, reflecting attention to interlinkages and the indivisibility of environmental, social and economic sustainability underlying Agenda 2030. In our analysis, it was understood to include vertical coherence across levels of governance, in addition to horizontal coherence across sectors.

association with the drivers and keywords and the implications of the relevant provisions (acknowledgement, concrete measure, tool or implementation mechanism) were assessed.

6.3 CBD, UNFCCC and the potential to mitigate the drivers of climate change and biodiversity loss

6.3.1 Convention on Biological Diversity (CBD)

Addressing direct and indirect drivers with potential for co-benefits

Concrete co-benefits of biodiversity conservation and climate change action are repeatedly pointed out through a variety of CBD COP decisions.[57] The CBD COP of 2004 included 'biodiversity and climate change' as a cross-cutting issue under its work. Since then, *climate change* has been increasingly addressed under the CBD, both as a driver of and being driven by biodiversity loss.[58] To address interactions of climate change and biodiversity loss, Parties to the CBD are encouraged to integrate climate concerns in their National Biodiversity Strategies and Action Plans (NBSAPs), and biodiversity and ecosystem-based approaches into their Nationally Determined Contributions (NDCs) under the UNFCCC.[59] Voluntary guidelines for the design and effective implementation of ecosystem-based approaches to climate change adaptation and disaster risk reduction were adopted by COP14.[60] Most of the relevant legal documents and guidelines under the CBD have focused on contributions to adaptation, even though Aichi target 15 explicitly includes the 'contribution of biodiversity to carbon stocks' and of ecosystem restoration to climate change mitigation and adaptation.[61] Climate change is reflected in none of the SDG 15 targets or indicators, underlining the Agenda 2030 logic of expressing interdependency at the level of goals rather than of targets.

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57 CBD, 'Climate change and biodiversity: background' (2017), available at <https://www.cbd.int/climate/background.shtml> (visited 28 March 2020).

58 'Biodiversity and climate change', CBD Dec. 14/5 (2018).

59 Ibid. at para. 4.

60 Ibid. at para. 1.

61 'The Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets', CBD Dec. 10/2 (2011), Annex, para. 13.

Preventing *land-use change* through the designation of networks of protected areas is one of the core aims of the CBD (Convention text, Article 8). The scope of this essential tool is defined in Aichi Target 11 of the current Strategic Plan, which calls for conservation of 'at least 17% of terrestrial and inland waters and 10% of coastal and marine areas, … are conserved' by 2020. This target is reflected in SDG target 15.1 which does not provide a percentage but refers to existing international agreements. In addition, Aichi Target 5 calls for halving and striving to completely reduce the loss of natural habitats and their degradation and fragmentation,[62] reflected in SDG target 15.3 ('By 2030, (…) strive to achieve a land degradation-neutral world.')

The post-2020 Global Biodiversity Framework (GBF) draft suggests an increase in ambition to 60 per cent coverage of sites of particular importance for biodiversity, including at least 30 per cent of land and seas globally, and at least 10 per cent under strict protection by 2030.[63] Building on this target, the zero draft of the post-2020 GBF calls for zero 'net loss' of ecosystems by 2030[64] and identifies restoration (also part of SDG targets 15.1, 15.2 and 15.3) as an important means to achieve 'net increase' of intact areas and wilderness by 2030.[65] In that sense, the post 2020 GBF is likely to increase ambition over the related SDG 15 targets, especially those that end by 2020 (15.1, 15.2 and 15.3).

Rehabilitation and restoration were first comprehensively addressed at COP11.[66] COP13 adopted a short-term plan of action and respective guidance on ecosystem restoration and integration of biodiversity concerns.[67] The CBD considers restoration as complementary to conservation, not substitute.[68] The most recent decision on biodiversity and climate change drives special attention to the role of wetlands (also included in SDG target 51.1) and states support for a joint declaration by relevant MEAs on peatland conservation and restoration.[69]

The CBD also addresses land use change through national and sectoral mainstreaming, incentive measures, environmental impact assessments (EIAs),

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62 Ibid., Annex

63 'Zero Draft of the post 2020 Global Biodiversity Framework', CBD Doc. CBD/WG2020/2/3 (2020), Annex, para. 12(a).

64 Ibid. at para. 10(a).

65 Ibid. at para 12(a).

66 CBD, 'Ecosystem restoration: background' (2016), available at <https://www.cbd.int/restoration/Background/> (visited 16 March 2020).

67 'Ecosystem restoration: short-term action plan', CBD Dec. 13/5 (2016), para. 1 and Annex.

68 Ibid. at para. 8.

69 'Biodiversity and climate change', CBD Dec. 14/5 (2018), para. 8.

strategic environmental assessments (SEAs) and, more recently, spatial planning.[70] To facilitate mainstreaming at the national level, Parties are requested to submit and regularly update their NBSAPs in accordance with Article 6 of the Convention (Sakiyama & Schwarzer, 2018).

The importance of the conservation and sustainable use of forests (SDG targets 15.1, 15.2 and 15b) for the achievement of the CBD objectives was acknowledged already at the very first COP in 1994. After COP2, forest issues were dealt with under the programme of work on forest biodiversity. Thereafter, highlights have been the introduction of the ecosystem approach to be applied to forest management as well as identification of synergies with the forest landscape restoration approach (Pistorius & Kiff, 2018, pp. 19–20). Focus of work on forests under the CBD has been much on developing indicators for forest biodiversity as well as streamlining of reporting.[71] In more recent decisions, CBD COP has acknowledged 'the strong congruence among the forest-related Aichi Biodiversity Targets, the four global objectives on forests, the forest-related provisions under the Paris Agreement'[72] and called on Parties to 'give due consideration to the conservation and sustainable use of natural forests and native vegetation and avoiding the potential negative impacts of afforestation of non-forest biomes'.[73] At COP14, the CBD Secretariat was requested to continue close collaboration with the United Nations Forum on Forests, the Global Partnership on Forest Landscape Restoration and the Collaborative Partnership on Forests, on, inter alia, data collection and spatial assessments to advance on biodiversity commitments.[74]

Further co-benefit potential lies in the CBD COP decision on mainstreaming of biodiversity in the energy and mining, infrastructure, manufacturing and processing sectors, which also takes the role of cities into account.[75] This relates much to *consumption and production patterns* as indirect drivers of both biodiversity loss and climate change that are reflected in Aichi target 4.[76] Despite repeated CBD calls for

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70 'Mainstreaming of biodiversity in the energy and mining, infrastructure, manufacturing and processing sectors', CBD Dec. 14/3 (2018), para. 13.

71 CBD, 'Forest biodiversity', available at <https://www.cbd.int/forest

72 'Forest biodiversity: the role of international organizations in supporting the achievement of the Aichi Biodiversity Targets', CBD Dec. 13/7 (2016), preamble.

73 Ibid., para 6

74 'Cooperation with other conventions, international organizations and initiatives', CBD Dec. 14/30 (2018) para. 35.

75 'Mainstreaming of biodiversity in the energy and mining, infrastructure, manufacturing and processing sectors', CBD Dec. 14/3 (2018).

76 'The Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets', CBD Dec. 10/2 (2010), Annex.

Sustainable Consumption and Production (SCP),[77] a clear definition and strong legal language are lacking. The same applies to the term 'transformational change' that has recently entered discussions on how to address drivers of biodiversity loss under the CBD.

Economic and technological drivers are mainly addressed in sectoral approaches under the CBD, on, for instance, agriculture and forestry, energy and mining. The most concrete references to trade and supply chains as well as strong legal language on sustainable production can be found in the decision text dealing with forestry[78] and fisheries.[79] Parties are urged, *inter alia*, to 'encourage sustainable forest management to achieve biodiversity outcomes, including by promoting sustainable consumption and production of forest products'[80] and 'improve enforcement and monitoring of sustainable forest management and the sustainability of timber trade'.[81] Moreover, COP decisions request the continuation or enhancement of collaboration with international organizations dealing with trade and production patterns such as the World Trade Organization (WTO) or sector-relevant organizations such as the Food and Agriculture Organization (FAO) and the International Tropical Timber Organization.[82] Domestically, CBD recommends mainstreaming of biodiversity considerations throughout sectors, national legislation and financial flows[83] and

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77 See, inter alia, ibid.; 'Strategic actions to enhance the implementation of the Strategic Plan for Biodiversity 2011-2020 and the achievement of the Aichi Biodiversity Targets, including with respect to mainstreaming and the integration of biodiversity within and across sectors', CBD Dec. 13/3 (2016); 'Updated assessment of progress towards selected Aichi Biodiversity Targets and options to accelerate progress', CBD Dec. 14/1 (2018); 'Scenarios for the 2050 Vision for Biodiversity', CBD Dec. 14/2 (2018); 'Mainstreaming of biodiversity in the energy and mining, infrastructure, manufacturing and processing sectors', CBD Dec. 14/3 (2018); 'Second work programme of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services', CBD Dec. 14/36 (2018).

78 See, for instance, 'Updated assessment of progress towards selected Aichi Biodiversity Targets and options to accelerate progress', CBD Dec. 14/1 (2018); 'Strategic actions to enhance the implementation of the Strategic Plan for Biodiversity 2011-2020 and the achievement of the Aichi Biodiversity Targets, including with respect to mainstreaming and the integration of biodiversity within and across sectors', CBD Dec. 13/3 (2016).

79 Ibid., paras 69, 71 and 72.

80 Ibid., para. 56.

81 'Updated assessment of progress towards selected Aichi Biodiversity Targets and options to accelerate progress', CBD Dec. 14/1 (2018), para. 14(e).

82 'Cooperation with other conventions, international organizations and initiatives', CBD Dec. 14/30 (2018).

83 See, for instance, 'Strategic actions to enhance the implementation of the Strategic Plan for Biodiversity 2011-2020 and the achievement of the Aichi Biodiversity Targets, including with respect to mainstreaming and the integration of biodiversity within and across sectors', CBD Dec. 13/3 (2016); and 'Mainstreaming of biodiversity in the energy and mining, infrastructure, manufacturing and processing sectors', CBD Dec. 14/3 (2018).

highlights the need to eliminate harmful incentives, including subsidies, and to increase positive incentives.[84]

Adverse impacts of fossil fuel extraction on biodiversity have gained attention, with the increased efforts to address mainstreaming of biodiversity into the energy and mining, infrastructure, manufacturing and processing sectors.[85] An according decision adopted in 2018 recognizes not only that these sectors affect biodiversity but also 'that the loss of biodiversity can impact these sectors negatively'.[86]

To address *governance and institutional drivers*, the mainstreaming approach, anchored in the Convention text itself,[87] can be considered the key tool promoted by the Convention. The CBD COP decisions also strongly call for increased policy coherence, at the national as well as at the international level. Close cooperation with other conventions and alignment with the Agenda 2030 are commonly referred to as central measures to alleviate incoherent governance.[88] Enhanced cooperation with other conventions, international organizations and initiatives has been explicitly dealt with by an informal advisory group on synergies under the CBD as well as through stand-alone COP decisions.[89] Initially highlighting primarily synergies with other biodiversity-related conventions, the scope has broadened over the past years through encouragement of 'consideration of actions for enhanced synergies among… the Rio Conventions, and other conventions… as they are essential for the implementation of the 2030 Agenda… and the Sustainable Development Goals'.[90] The CBD is also increasingly drawing on information provided by the IPCC and referring to provisions made under the UNFCCC.[91]

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84 'The Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets (2010)', CBD Dec. 10/2 (2010), Annex, target 3.

85 'Strategic actions to enhance the implementation of the Strategic Plan for Biodiversity 2011-2020 and the achievement of the Aichi Biodiversity Targets, including with respect to mainstreaming and the integration of biodiversity within and across sectors', CBD Dec. 13/3 (2016).

86 'Mainstreaming of biodiversity in the energy and mining, infrastructure, manufacturing and processing sectors', CBD Dec. 14/3 (2018), preamble.

87 CBD, 'Biodiversity mainstreaming', available at <https://www.cbd.int/mainstreaming/> (visited 26 March 2020).

88 See, for instance, 'Updated assessment of progress towards selected Aichi Biodiversity Targets and options to accelerate progress', CBD Dec. 14/1 (2018), Annex, para. 2(h)

89 See, for instance, 'Cooperation with other conventions, international organizations and initiatives', CBD Dec. 14/30 (2018).

90 Ibid. at paras 3 and 4.

91 'Biodiversity and climate change', CBD Dec. 14/5 (2018).

Nevertheless, strong legal language on coherence only applies to national planning obligations and mainstreaming, as set out in Article 6 (a and b) of the Convention. In addition, Parties are encouraged ‘to explore possible synergies at the national level, involving all relevant biodiversity-related reporting processes, in order to enhance the alignment and consistency of information and data in national reports’.[92] COP14 also highlighted the related need for indicator alignment ‘across different reporting processes on biodiversity and sustainable development’.[93]

Addressing potential trade-offs

Potential *trade-offs from climate action for biodiversity* are addressed most specifically by the CBD with regard to forests, in particular REDD+, climate-related geoengineering and biofuels. The special attention given to forests and their emission mitigation potential under the UNFCCC through, inter alia, REDD+ has been addressed at CBD COP10 when Parties called for the enhancement of benefits for, and avoidance of negative impacts on biodiversity from REDD+.[94] At CBD COP11, Parties adopted advice on biodiversity safeguards to be applied by REDD+ and other efforts under the UNFCCC.[95]

Geoengineering activities affecting biodiversity are largely rejected. In COP decision X/33, Parties commit to ‘ensure […] that no climate-related geo-engineering activities** that may affect biodiversity take place, until there is an adequate scientific basis on which to justify such activities and appropriate consideration of the associated risks’.[96]

Biofuels are addressed by the CBD, but without clear rules, guidelines or legal implications. COP9 broadly discussed biofuels as part of the work programme on agricultural biodiversity and Parties agreed that ‘biofuel production and use should be sustainable in relation to biological diversity’.[97] To ensure this, Parties were urged to develop coherent policy frameworks and to support technology transfer and best

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92 ‘Process for aligning national reporting, assessment and review’, CBD Dec. 14/27 (2018), para. 2.

93 ‘Tools to evaluate the effectiveness of policy instruments for the implementation of the Strategic Plan for Biodiversity 2011-2020’, CBD Dec.14/28 (2018), para. 2.

94 ‘Biodiversity and climate change’, CBD Dec. 10/33 (2010), para. 8(q).

95 ‘Biodiversity and climate change related issues: advice on the application of relevant safeguards for biodiversity with regard to policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries’, CBD Dec. 11/19 (2012).

96 CBD, ‘Climate-related Geoengineering and Biodiversity’, available at <https://www.cbd.int/climate/geoengineering/> (visited 25 March 2020); ‘Biodiversity and climate change’, CBD Dec. 10/33 (2010).

97 ‘Agricultural biodiversity: biofuels and biodiversity’, CBD Dec. 9/2 (2008), para. 1.

practice exchange.[98] At COP10, Parties were explicitly invited to develop national inventories and conduct spatial assessment to identify potential areas for biofuel production without harming biodiversity.[99] At the same time, the Secretariat was requested to compile tools and approaches 'to assess direct and indirect effects and impacts on biodiversity of the production and use of biofuels'.[100]

Trade-offs from biodiversity protection measures for climate change mitigation are poorly addressed in the CBD. For instance, the designation of protected areas as one of the major tools of the CBD can bear potential trade-offs for renewable energy projects, but such limitations are not addressed. Moreover, there is no mention of the time needed for restored ecosystems to provide the full extent of their ecosystem services which may also cause (temporary) trade-offs for mitigation targets, depending on the purpose they have been designed for (Favretto et al., 2018). This is especially relevant for the current suggestion of a long-term goal on '[n]o net loss by 2030 in the area and integrity of freshwater, marine and terrestrial ecosystems, and increases of at least [20 per cent] by 2050, ensuring ecosystem resilience' in the zero draft of the post-2020 GBF,[101] which allows for offsetting ecosystem destruction by restoring an equal area elsewhere. Time lags in regaining the full carbon stocks of the lost areas in the restored areas have not been resolved (Moreno-Mateos et al., 2015). The most explicit recognition of the need to avoid trade-offs from biodiversity conservation measures affecting climate change mitigation can be found in the safeguards of the voluntary ecosystem-based approaches (EbA) guidelines: 'EbA and Eco-DRR[102] should neither result in unsustainable resource use nor enhance the drivers of climate change and disaster risks'.[103]

Gaps concerning potential for synergies

Overall, the CBD and the analysed legal documents maintain a fairly holistic approach in addressing drivers and pointing out potential for co-benefits and synergies. However, a clear gap can be perceived in terms of obligations: the overall legal language of the CBD and its COP decisions is rather weak, and the majority of measures suggested remain at the level of recommendations to Parties – except for the obligation to develop, update and report on national plans and to designate

98 Ibid., paras 3 and 6.

99 Biofuels and biodiversity'. CBD Dec. 10/37 (2010), para 7.

100 Ibid., para. 11(a).

101 'Zero Draft of the post 2020 Global Biodiversity Framework' CBD Doc. CBD/WG2020/2/3 (2020), Annex, para. 10

102 Ecosystem-based approaches to disaster risk reduction.

103 'Biodiversity and climate change', CBD Dec. 14/5 (2018), Annex, Section 2.2.

networks of protected areas. The Strategic Plan sets concrete targets, but these refer to the global level and hence only provide guidance for individual national goals.

In addition, several fields of potential synergies need further consideration, as they are not yet sufficiently explored or anchored in legal text. This is the case for addressing most of the socio-cultural and technological drivers, for instance through joint capacity-building across sectors and with other conventions. Accordingly, COP13 and COP14 decisions requested the Executive Secretary to further promote more systemic and integrated approaches.[104] Progress in this regard, and thereby towards the achievement of the SDGs, relies on enhanced technical and scientific cooperation. Potential for increased synergy can also be identified regarding communication, education and public awareness efforts.

Streamlining of future mainstreaming and reporting obligations represents a necessary enhancement of governance mechanisms and reporting requirements set under the Agenda 2030. They are key in enabling governments to better align their efforts on biodiversity conservation and climate change mitigation, harness synergies and lower administrative burden which is of particular importance for developing countries. Incentives and subsidies are clearly another field under the CBD where synergies could be investigated further.

Regarding land use, attempts to increase synergies could make use of more comprehensive guidance on the application of the land- and seascape approach and integrated spatial planning in the legal documents of the CBD. While synergies in forestry have been addressed in particular concerning REDD+, co-benefits in the field of agriculture are not specified in an equal manner. Regarding specific measures to address common direct drivers, the contribution of biodiversity conservation to climate change mitigation efforts clearly necessitates practical guidance for Parties.

The highest potential for enhanced synergies lies with no doubt in more decisively addressing indirect drivers such as consumption and production, but also more specifically, setting ambitious and binding sectoral targets, in line with relevant SDG targets, for instance on food production (SDG target 12.3) and pollution (SDG targets 12.4 and 12.5). Limitations in this regard arise from the legal mandate of the CBD. For a complete overview of our analysis results, see Table 6.1.

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104 'Capacity-building, technical and scientific cooperation, technology transfer and the clearing-house mechanism', CBD Dec. 13/23 (2016), preamble; 'Capacity-building and technical and scientific cooperation', CBD Dec. 14/24 (2018), preamble.

Table 6.1 Analysis of CBD documents with regard to direct and indirect drives of climate change and biodiversity loss and other relevant keywords.

Legend	
Low	Low relevance - text mentioned in preamble or annex
Medium	Medium relevance - text mentioned in the operational part with general wording
High	High relevance - text mentioned in the operational part with concrete measures; possibly hard legal language used*
Not addressed	Not addressed

Notes on legend: * Hard legal language in the analyzed CBD COP decisions is scarce and Parties are only in a very few cases "urged" to take specific action. "Shall" is only used in the text of the convention. High relevance has additionally been indicated when drivers or key words (a) were dealt with in stand alone decisions on the topic or (b) were namely included in targets under the Strategic Plan or Zero-Draft of the post-2020 GBF - even though their remains unclarity about the legal status of the post-2020 GBF.

ANALYSED DOCUMENTS	INDIRECT DRIVERS		
	Demographic & socio-cultural	Economic & technological	Governance & institutions
Convention on Biological Diversity	Low	Low	Low
Strategic Plan 2011-2020	High	Medium	High
Subsequent COP decisions on the Strategic Plan 2011-2020	High	Medium	High
Zero draft of post 2020 GBF	High	High	High
COP decisions related to climate change	Not addressed	Not addressed	Not addressed
COP decisions on protected areas and ecosystem restoration	Low	Low	Medium
COP decision on forest biodiversity	Not addressed	Not addressed	Low
COP decision on agricultural biodiversity	Not addressed	Medium	High
COP decision on mainstreaming in industry	Not addressed	High	Medium
COP decisions on national reporting	Not addressed	Not addressed	High
COP decisions on capacity-building and cooperation	Not addressed	High	High

ANALYSED DOCUMENTS	DIRECT DRIVERS		
	Fossil fuels	Land-/sea-use change	Climate change
Convention on Biological Diversity	Not addressed	High	Not addressed
Strategic Plan 2011-2020	Not addressed	High	High
Subsequent COP decisions on the Strategic Plan 2011-2020	Not addressed	High	Low

ANALYSED DOCUMENTS	DIRECT DRIVERS		
	Fossil fuels	Land-/sea-use change	Climate change
Zero draft of post 2020 GBF			
COP decisions related to climate change			
COP decisions on protected areas and ecosystem restoration			
COP decision on forest biodiversity			
COP decision on agricultural biodiversity			
COP decision on mainstreaming in industry			
COP decisions on national reporting			
COP decisions on capacity-building and cooperation			

ANALYSED DOCU-MENTS	OTHER KEYWORDS			
	Food security, Production & Consumption/ Agriculture	Land-/sea-use Environment/ Biodiversity/ Ecosystems/ Forests	Policy coherence	Sustainable Con-sumption and Production
Convention on Biological Diversity				
Strategic Plan 2011-2020				
Subsequent COP decisions on the Strategic Plan 2011-2020				
Zero draft of post 2020 GBF				
COP decisions related to climate change				
COP decisions on protected areas and ecosystem restoration				
COP decision on forest biodiversity				
COP decision on agricultural biodiversity				
COP decision on mainstreaming in industry				

ANALYSED DOCUMENTS	OTHER KEYWORDS			
	Food security, Production & Consumption/ Agriculture	Land-/sea-use Environment/ Biodiversity/ Ecosystems/ Forests	Policy coherence	Sustainable Consumption and Production
COP decisions on national reporting				
COP decisions on capacity-building and cooperation				

6.3.2 United Nations Framework Convention on Climate Change (UNFCCC)

Addressing direct and indirect drivers with potential for co-benefits

Land use change is one of the key drivers of climate change, accounting for a substantial share of GHG emissions globally. As a result, land use, land-use change and forestry (LULUCF) is one of the major sectors addressed by the UNFCCC legal documents, with multiple decisions exclusively dedicated to this sector, addressing interaction between SDGs 13 and 15; in particular targets 15.1-15.5 which focus on the protection, restoration and sustainable management of forest and other ecosystems, as well as land restoration and degradation prevention. Moreover, the importance of terrestrial and marine ecosystems as sinks and reservoirs of GHG emissions was already recognized in the Convention and the development of methodologies for estimating their net effect on GHG emissions (including as sources) was tasked to the COP.

While forestry and ecosystems were initially not included in the list of core sectors of the Kyoto Protocol (only agriculture, Annex B), countries where LULUCF represented a source of emissions in 1990 were requested to include these net emissions in their baseline. Common reporting formats for LULUCF GHG emissions are imposed through the COP Decision 14/CP.11,[105] where countries are required to use guidelines and methodologies developed by the IPCC (Penman et al., 2003). Yet, under the Paris Agreement, it is compulsory only for developed countries to account for economy-wide emission in their NDCs, including LULUCF as a sector, while developing countries

105 'Tables of the common reporting format for land use, land-use change and forestry', UNFCCC Dec. 14/CP.11 (2005).

can limit their sectoral reporting. Through Decision 1/CP.16,[106] developing countries that wish to have land-use activities funded must prepare national strategies or action plans. In such situations, they are requested to develop national monitoring systems for forest-related GHG emissions levels or reference levels, and to report on consideration of safeguards (strengthened in subsequent decisions[107]), including environmental protection. Decision 9/CP.19[108] establishes an information hub web platform to ensure transparency and mutual learning from these activities. In the forestry sector specifically, the following activities apply: reducing emissions from deforestation and from forest degradation; conservation of forest carbon stocks; sustainable management of forests; and enhancement of forest carbon stocks.[109] These activities are facilitated through the REDD+ mechanism, supporting SDG target 15.2 on forests.

The Paris Agreement encourages Parties 'to implement and support… the existing framework [on forest-related activities] … while reaffirming the importance of incentivizing, as appropriate, non-carbon benefits associated with such approaches' (Paris Agreement, Article 5(2)). Earlier relevant decisions on LULUCF-related matters recognize that promoting sustainable management of forests and co-benefits, including biodiversity and ecosystem resilience would lead to synergies with national and international forestry objectives.[110] Moreover, climate change itself is recognized as a driver of biodiversity loss in the UNFCCC and key documents, including the Paris Agreement, indicating that adaptation measures should be taken to enhance the resilience of ecosystems (for instance, in Article 4 of the Paris Agreement).

Economic and technological drivers are primarily addressed through references to production and clean technologies in the international climate legislation. 'Accele-

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106 'The Cancun Agreements: Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention', UNFCCC Dec. 1/CP.16 (2010).

107 See, for instance, 'Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention', UNFCCC Dec. 2/CP.17 (2011); 'The timing and the frequency of presentations of the summary of information on how all the safeguards referred to in Dec. 1/CP.16, appendix I, are being addressed and respected', UNFCCC Dec. 12/CP.19 (2013); 'Guidelines and procedures for the technical assessment of submissions from Parties on proposed forest reference emission levels and/or forest reference levels', UNFCCC Dec. 13/CP.19 (2013); 'Modalities for measuring, reporting and verifying', UNFCCC Dec. 14/CP.19 (2013).

108 'Work programme on results-based finance to progress the full implementation of the activities referred to in Dec. 1/CP.16, paragraph 70', UNFCCC Dec. 9/CP.19 (2013).

109 'The Cancun Agreements: Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention', UNFCCC Dec. 1/CP.16 (2010).

110 'Methodological guidance for activities relating to reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries', UNFCCC Dec. 4/CP.15 (2009); 'Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention', UNFCCC Dec. 2/CP.17 (2011).

rating, encouraging and enabling innovation is critical for an effective, long-term global response to climate change… Such effort shall be, as appropriate, supported, including by the Technology Mechanism and, through financial means, by the Financial Mechanism of the Convention' (Paris Agreement, Article 10(5)). In that regard, developed countries (under Annex I and Annex II of the UNFCCC) were strongly requested to promote, facilitate and finance the development and transfer of 'environmentally sound technologies' to other Parties already through the Convention. To that end, the Subsidiary Body for Scientific and Technological Advice (SBSTA) is mandated to support countries with the latest available information. Moreover, the Copenhagen Accord decided the establishment of the Technology Mechanism to enhance development and transfer of relevant technologies across countries. The Kyoto Protocol provides a number of measures that countries could take to reduce their emissions, including enhancement of energy efficiency and promotion of technologies such as renewables and carbon dioxide sequestration (Kyoto Protocol, Article 2). More complete lists of technologies and potential measures are provided through guiding documents and the reports of the IPCC (e.g. see, for instance, IPCC, 2014).[111]

The UNFCCC strongly highlights that climate measures should seek to avoid adverse effects on national economies and should be taken within a timeframe that 'enable[s] economic development to proceed in a sustainable manner', recognizing 'the special difficulties of those countries … whose economies are particularly dependent on fossil fuel production, use and exportation' (UNFCCC Convention text, Objective and Preamble) to reduce GHG emissions. Specific measures to address economic drivers of climate change are not provided in the main legal documents assessed in this paper (except for agriculture and forest-related activities specifically), but the economic sectors (including subsectors) of climate action are made most concrete in Annex A of the Kyoto Protocol: energy (fuel combustion and fugitive emissions from fuels); industrial processes; solvent and other products; agriculture; and waste, plus related subsectors. Relevant co-benefits of economic diversification plans are officially accepted as contributions to mitigation action in the Paris Agreement (Article 10(5)).

The strength of international climate legislation is in addressing *governance drivers*. It is meant to support coordination across the international community, strongly encouraging and facilitating cooperation amongst all countries in tackling the climate

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111 See, for instance, UNFCCC Consultative Group of Experts on National Communications from parties not included in Annex I to the Convention, 'Training Handbook for Mitigation Assessment for Non-Annex I parties' (2006), available at https://unfccc.int/resource/cd_roms/na1/mitigation/Handbook/MitigationHandbook_11May2006.pdf (visited 24 April 2020)

crisis. Strong legal language is used to ensure cooperation in providing international financial, technological and capacity-building support and to establish supporting bodies such as the Green Climate Fund or the Technology Mechanism. Moreover, instruments such as Emissions Trading, Clean Development Mechanism and Joint Implementation were developed under the Kyoto Protocol (Articles 6, 12 and 17) to facilitate cooperation within and between countries in reaching climate goals through trading of Emissions Reduction Units (REUs), including from land-related activities. These measures are aligned with the SDG 13 demand that developed countries keep their commitment of climate finance provision to developing countries (target 13.a) as well as the promotion of mechanisms that support capacity-building for climate-related planning and management in the least developed countries and the small island developing states (target 13.b). In particular, the Paris Agreement's request for all countries to put forward NDCs to jointly reach the global target of a maximum temperature increase of 2ºC, is a strong example of global coordination of action.

Moreover, key governance measures to tackle emissions nationally are suggested in some of the agreements and decisions, such as to directly address market imperfections, fiscal incentives, tax and duty exemptions and subsidies that lead to GHG emissions in all sectors (Kyoto Protocol, Article 2(1)).

The UNFCCC also shows extensive support for capacity-building (also reflected under SDG targets 13.b and 17.9). Already in the Convention, SBSTA was tasked to 'identify ways and means of supporting endogenous capacity-building in developing countries' (UNFCCC Convention text, Article 9) and it remains a key part of international support in global climate governance. Additionally, promoting education, training and awareness raising on climate-related issues (with an assigned SDG 13 target, see 13.2) is emphasized throughout, with a dedicated article in the Convention itself, Article 6, which uses strong legal language.

Addressing potential trade-offs

While the UNFCCC recognizes that 'various actions to address climate change can be justified economically in their own right and can also help in solving other environmental problems' (UNFCCC, Convention text, Preamble), it also stays mindful of potential trade-offs with other social, environmental and economic dimensions. Since the establishment of the Climate Convention, countries were expected to 'take climate change considerations into account… in their relevant social, economic and environmental policies and actions, and employ appropriate methods… to minimizing adverse effects on the economy, on public health and on the quality of the environment, of projects or measures undertaken by them to mitigate or adapt to climate change' (UNFCCC, Convention text, Article 4(1f)). This is also in line with the

SDG target 13.2 ‘Integrate climate change measures into national policies, strategies and planning’ and reflects the call for policy coherence under target 17.14. While the specific potential environmental trade-offs that need to be addressed are not clarified in the legal documents, a reference is made to key strands of international environmental law that Parties should ensure consistency with in their actions, such as the United Nations Forum on Forests, the United Nations Convention to Combat Desertification and the Convention on Biological Diversity.[112]

Decision 1/CP.16 is a key decision in this regard, establishing relevant guidelines for Parties activities in the LULUCF sector and requesting countries to consider essential safeguards. This decision provides that activities should ‘d) Be consistent with the objective of environmental integrity and take into account the multiple functions of forests and other ecosystems;’, ‘f) Be consistent with Parties’ national sustainable development needs and goals;’ and ‘k) Promote sustainable management of forests’[113]. The safeguards to be promoted include consistency with the objectives of national forest programmes and international agreements and conventions (with no specific mention) and ensured consistency with natural forest conservation and biodiversity protection while also enhancing other social and environmental benefits (with relevance for SDG targets 15.1-15.5 and 15.8).[114] Subsequent decisions request parties to report on these safeguards.

While extensive use of biofuels as well as agricultural activities for food production or other purposes can also lead to significant trade-offs with SDG 15, current strands of work under UNFCCC do not specifically address these potential issues. In general, agriculture and biofuels have not been addressed as extensively as forest-related activities and the current Koronivia Joint Work on Agriculture is still relatively recent and under further development.[115]

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112 ‘Reducing emissions from deforestation in developing countries: approaches to stimulate action’, UNFCCC Dec. 2/CP.13 (2007).

113 ‘The Cancun Agreements: Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention‘, UNFCCC Dec. 1/CP.16 (2010), Appendix I, para. 1.

114 Ibid. at Appendix I, para. 2

115 UNFCCC, ‘Issues Related to Agriculture’, available at <https://unfccc.int/topics/land-use/workstreams/agriculture>

Table 6.2 Analysis of UNFCCC documents with regard to direct and indirect drives of climate change and biodiversity loss and other relevant keywords.

- Low relevance - text mentioned in preamble or annex
- Medium relevance - text mentioned in the operational part with general wording
- High relevance - text mentioned in the operational part with concrete measures; possibly hard legal language used*
- Not addressed

Notes on legend: Drivers and topics (keywords) were considered to be insufficiently addressed (low relevance) if the matter only appeared in the preamble. Stronger relevance was indicated in the case of inclusion of the key drivers or topics in the operational part of the documents. Legal language such as 'note', 'recognize', 'acknowledge', as well as 'invite' or 'encourage' was considered to represent soft law (medium relevance), while wording such as 'shall', 'will' or 'request' was marked as strong legal language (high relevance). The establishment of key international mechanisms relevant to respective topics (e.g. Technology Mechanism) were included under 'high relevance'.

ANALYSED DOCUMENTS	INDIRECT DRIVERS		
	Demographic & socio-cultural	Economic & technological	Governance & institutions
Framework Convention	High	High	High
Kyoto Protocol	High	High	High
Copenhagen Accord	Medium	High	High
Paris Agreement	High	High	High
Katowice COP/CMP/CMA	High	High	High
Madrid COP/CMP/CMA	High	High	High
LULUCF COP decisions	High	High	High

ANALYSED DOCUMENTS	DIRECT DRIVERS		
	Fossil fuels	Land-/sea-use change	Climate change
Framework Convention	Medium	High	High
Kyoto Protocol	High	High	High
Copenhagen Accord	Not addressed	Medium	Medium
Paris Agreement	Not addressed	High	High
Katowice COP/CMP/CMA	High	High	High
Madrid COP/CMP/CMA	Medium	Medium	High
LULUCF COP decisions	Not addressed	High	High

ANALYSED DOCUMENTS	OTHER KEYWORDS			
	Food security, Production & Consumption/ Agriculture	Land-/sea-use Environment/ Biodiversity/ Ecosystems/ Forests	Policy coherence	Sustainable Consumption and Production
Framework Convention				
Kyoto Protocol				
Copenhagen Accord				
Paris Agreement				
Katowice COP/CMP/ CMA				
Madrid COP/CMP/CMA				
LULUCF COP decisions				

6.3.2.3 Gaps concerning potential for synergies

A sector that could be better addressed to ensure synergies is the *agricultural sector*. While agriculture has been recognized as a relevant sector for GHG emissions reductions and was included in the list of reporting under the Kyoto Protocol, there is limited mention of related trade-offs and synergies and little work has been done so far. In fact, the most important work on agriculture has been initiated at COP23, where Decision 4/CP.23 adopted the 'Koronivia Joint Work on Agriculture'.[116] In the initial phase of this joint work, the work group was mandated to address a number of issues, including with a view to soil health and fertility (SDG target 15.3), improving sustainability of the agricultural systems, and the socioeconomic and food security dimensions. However, no reference is made to the environmental dimension and the lack of a clear definition of the meaning of 'sustainability' could leave this dimension inadequately addressed.

Another key area that could be enhanced to address both biodiversity loss and climate change is trade. So far UNFCCC makes very little reference to trade as a driver of climate change. The Convention only highlights that climate measures should not take the form of 'disguised restriction on international trade' (UNFCCC, Convention text, Article 3(5)) further enforced by the Kyoto Protocol (Article 4(8h)).

Yet, adequate standards along supply chains could ensure global improvements in production from the perspective of GHG emissions and of biodiversity loss. Such

116 'Koronivia joint work on agriculture', UNFCCC Dec. 4/CP.23 (2017).

standards could reduce consumption of fossil fuels and would ensure sustainability in the use of land resources and ecosystems. However, given the fact that countries determine their emissions levels only based on domestic production activities, there is little incentive to reduce imported GHG emissions and the related consumption.

While UNFCCC's work addresses production through various measures, very little emphasis is placed on *consumption*. In the early years of international climate negotiations, consumption was mainly discussed in the context of vulnerability to climate mitigation measures, where countries with high consumption of fossil fuels or energy-intensive products were seen as particularly vulnerable and in need of international support (Kyoto Protocol, Article 4). The Paris Agreement is the first to recognize that 'sustainable lifestyles and sustainable patterns of consumption and production, with developed country Parties taking the lead, play an important role in addressing climate change' (Paris Agreement, Preamble). A stronger emphasis on, for instance, sustainable consumption nudges, such as sustainability labels, could support achieving the targets of both Conventions. For a complete overview of our analysis results, see Table 6.2.

6.4 UN Environmental Assembly and SDG interactions

The four United Nations Environment Assembly sessions convened so far, since 2014, have taken place in the post-2015 Development Agenda era. The first UNEA session was themed 'Sustainable Development Goals and the Post-2015 Development Agenda, including sustainable consumption and production', the second one 'Delivering on the Environmental Dimension of the 2030 Agenda, the third one 'Towards a pollution-free planet' and the fourth one 'Innovative solutions for environmental challenges and sustainable consumption and production'. These titles hold promise for addressing interactions between different sustainable development challenges, including those concerning SDGs 13 and 15. However, the UNEAs have done so to varying degrees.

References to halting climate change and biodiversity loss have gradually increased in the outcome documents of the four UNEA sessions. The Ministerial declaration of UNEA-1 called on the international community 'To undertake urgent actions to address climate change . . . and to reinforce efforts to halt biodiversity loss and combat desertification.'[117] At the second session, UNEA adopted five specific resolutions addressing climate change and biodiversity out of 25 resolutions totally adopted.[118] Within the third session and its Ministerial declaration, climate change and biodiversity loss drivers were addressed in four resolutions out of a total number of eleven adopted resolutions.[119] Both direct and indirect drivers have been addressed in the UNEA resolutions, but typically in a separate manner.

Attention to interactions has been largely implicit, though a few explicit references to synergies between efforts to halt biodiversity loss and climate action could also be found. Resolution 1/8 of UNEA-1 on 'Ecosystem-based adaptation' explicitly recognized the importance 'to include and improve ecosystem-based adaptation and community-based adaptation in their national policies, including those on climate change adaptation, food security and sustainable management of forests'. The Resolution addressed the ecosystem-based adaptation mainly from the governance perspective and urged 'all Member States to ratify, accept or approve the Paris Agreement'. UNEA-2 Resolutions 2/6 'Supporting the Paris Agreement' and 2/17 'Enhancing the work of the United Nations Environment Programme in facilitating cooperation, collaboration and synergies among biodiversity-related conventions' address both climate change and biodiversity loss from a governance and policy coherence perspective. In Resolution 2/17, climate change is highlighted was a direct driver of biodiversity loss, but later UNEA sessions did not emphasize this interlinkage.

Despite its focus on pollution, an increased attention to interactions is reflected in the Ministerial declaration of UNEA-3. In the declaration, the Ministers of environment 'acknowledge the links between pollution, climate change, biodiversity loss and ecosystem degradation'. Specific attention was also given to unsustainable land use: 'unsustainable land use and management can lead to soil degradation and pollution and create phenomena such as forest and biodiversity loss.'[120] In the specific

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117 'Ministerial outcome document of the first session of the United Nations Environment Assembly of the United Nations Environment Programme', UNEA Res. 1/1 (2014).

118 'Supporting the Paris Agreement', UNEA Res. 2/6; 'Sustainable coral reef management', UNEA Res. 2/12; 'Sustainable management of natural capital for sustainable development and poverty eradication', UNEA Res. 2/13; 'Mainstreaming of biodiversity for well-being', UNEA Res. 2/16; 'Enhancing the work of the United Nations Environment Programme in facilitating cooperation, collaboration and synergies among biodiversity-related conventions', UNEA Res. 2/17 (2006).

119 'Pollution mitigation by mainstreaming biodiversity into key sectors', UNEA Res. 3/2; 'Environment and health', UNEA Res. 3/4; 'Investing in innovative environmental solutions for accelerating the implementation of the Sustainable Development Goals', UNEA Res. 3/5; 'Managing soil pollution to achieve sustainable development', UNEA Res. 3/6 (2017).

120 Ministerial declaration of the United Nations Environment Assembly at its third session 'Towards a pollution-free planet', UN Doc. UNEP/EA.3/HLS.1 (2018).

Resolution 3/6, soil pollution and land use are connected to achieving the SDGs: 'soil is one of the largest reservoirs of biodiversity and that the negative impacts of the contamination of soil undermine productivity and sustainability of ecosystems, biodiversity, agriculture and food security, and clean ground and surface water, potentially hampering the achievement of the Sustainable Development Goals, including Goals 1, 2, 3, 6, 12, 13 and 15.'[121] Resolution 3/2 encourages 'investments in biodiversity as a means of enhancing the functioning of ecosystems and the services they provide.'[122] Interactions between climate change, biodiversity loss and health are recognized in the Resolution 3/4 'Environment and health'.

At UNEA-4, actions with potential to create co-benefits for the climate and biodiversity, both terrestrial as well as marine biodiversity, received explicit attention. The Environment Assembly adopted resolutions addressing, for instance, innovations to halt biodiversity and land degradation, sustainable management of mangroves, coral reefs, rangelands and pastoralism, and conservation of peatlands.[123] In the Ministerial declaration, the Ministers committed to developing 'an ambitious and realistic post-2020 global biodiversity framework' which is expected to be adopted at the 15th CBD COP, to be held in China in 2021.[124] In the Resolution 4/10 'Innovation on biodiversity and land degradation', it is recognized that 'climate change is a major and growing driver of biodiversity loss and ecosystem degradation, and that conservation and sustainable use of biodiversity, and ecosystem functions and services, contribute significantly to climate change adaptation and mitigation, disaster risk reduction, and food security and nutrition'. Resolution 4/12 'Sustainable management for global health of mangroves' mentions 'mangroves as an important but fragile ecosystem of invaluable biological diversity that provides vital ecosystem services which are contributing to the anticipated achievement by 2020 of Sustainable Development Goals 2 and 13 and targets 14.2 and 15.5 '. The Assembly encourages Member States to improve research, education and public awareness, build capacity for the sustainable management and restoration of mangroves and related ecosystems… to prepare multipurpose management plans for mangroves, based on scientific information… and invites Member States to take action to prevent man-

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121 'Managing soil pollution to achieve sustainable development', UNEA Res. 3/6 (2017).

122 'Pollution mitigation by mainstreaming biodiversity into key sectors', UNEA Res. 3/2 (2017).

123 'Innovation on biodiversity and land degradation', UNEA Res. 4/10; 'Sustainable management for global health of mangroves', UNEA Res. 4/12; 'Sustainable coral reefs management', UNEA Res. 4/13; 'Conservation and sustainable management of peatlands', UNEA Res. 4/16 (2019).

124 'Innovative solutions for environmental challenges and sustainable consumption and production', Ministerial declaration of the United Nations Environment Assembly at its fourth session, UN Doc. UNEP/EA.4/HLS (2019).

grove forest conversion, strengthen measures to maintain their integrity and give priority to conserving remaining areas of natural mangrove forests.[125]

The Resolution 4/16 on 'Conservation and sustainable management of peatlands' addresses land use as a direct driver and focuses on governance as an indirect driver. The Assembly, 'recognizing also that actions to advance sustainable peatland conservation and sustainable management can also contribute to addressing climate change… urges Member States and other stakeholders to give greater emphasis to the conservation, sustainable management and restoration of peatlands worldwide.'[126]

Regarding conservation and sustainable use of forests, the EU and its Member States presented at UNEA-4 a resolution titled 'Deforestation and agricultural commodity supply chains' as a global call to halt deforestation while contributing to ensure food security and nutrition. However, the resolution failed to be approved by the Assembly as no consensus was reached during the negotiation phase. The failure of this resolution potentially represents a missed opportunity in addressing the interactions between forest use and agriculture within UNEA.

The strong and repeated attention of UNEA on sustainable production and consumption (SCP) targets one of the key indirect drivers of climate change and biodiversity loss. SCP has been a central theme of UNEA since its first session, where the Ministerial declaration called 'on the international community… to accelerate and support efforts to promote sustainable consumption and production patterns… and to accelerate actions… to implement the 10-year framework of programmes on sustainable consumption and production.' At UNEA-2, the Resolution 2/8 'Sustainable consumption and production' echoed SDG 12 but also recognized the role of SCP policies in achieving other sustainability objectives: 'SCP approaches and policies at all levels… can be useful tools for improving sustainability in different areas, including urban planning, natural resource conservation, resources management, land use management and nutrient management, which can be promoted through regional frameworks and forums and other initiatives.'[127]

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125 'Sustainable management for global health of mangroves', UNEA Res. 4/12 (2019).

126 'Conservation and sustainable management of peatlands', UNEA Res. 4/16 (2019).

127 Sustainable consumption and production', UNEA Res. 2/8 (2016).

Table 6.3 Analysis of UNEA documents with regard to direct and indirect drives of climate change and biodiversity loss and other relevant keywords.

- Low relevance - text mentioned in preamble or annex
- Medium relevance - text mentioned in the operational part with general wording
- High relevance - text mentioned in the operational part with concrete measures; possibly hard legal language used*
- Not addressed

Notes on the legend: UNEA documents are not legally binding and therefore "hard legal language" is meant to be in UNEA documents the use of stronger wording in addressing Member States and/or UNEP's Executive Director such as "urge" and/or "request".

ANALYSED DOCUMENTS	INDIRECT DRIVERS		
	Demographic & socio-cultural	Economic & technological	Governance & institutions
UNEA-1 Ministerial Declaration	Not addressed	Not addressed	Not addressed
Resolution 1/8 - Ecosystem-based adaptation	Not addressed	Not addressed	Medium relevance
Resolution 2/6 - Supporting the Paris Agreement	Not addressed	Not addressed	High relevance
Resolution 2/8 - SCP	Not addressed	Not addressed	Not addressed
Resolution 2/12 - Sustainable coral reef	High relevance	High relevance	High relevance
Resolution 2/13 - Sustainable management	Not addressed	High relevance	Not addressed
Resolution 2/16 -Mainstreaming of biodiversity	Not addressed	Medium relevance	Not addressed
Resolution 2/17 - Enhancing the work of UNEP	Not addressed	Not addressed	High relevance
UNEA-3 Ministerial outcome document	Medium relevance	Not addressed	Not addressed
Resolution 3/2 - Pollution mitigation	Not addressed	High relevance	Not addressed
Resolution 3/4 - Environment and health	Medium relevance	Not addressed	Medium relevance
Resolution 3/5 - Investing in innovative solutions	Not addressed	Medium relevance	Not addressed
Resolution 3/6 - Managing soil pollution	Not addressed	Not addressed	High relevance
UNEA-4 Ministerial Outcome Document	Not addressed	Low relevance	Not addressed
Resolution 4/1 - Innovative pathways to SCP	Not addressed	Medium relevance	Medium relevance
Resolution 4/10 - Innovation on biodiversity	Not addressed	Medium relevance	High relevance
Resolution 4/12 - Sustainable management	Medium relevance	Not addressed	High relevance
Resolution 4/13 - Sustainable coral reefs	Not addressed	Not addressed	High relevance
Resolution 4/16 - Conservation of peatlands	Not addressed	Not addressed	High relevance

ANALYSED DOCUMENTS	DIRECT DRIVERS		
	Fossil fuels	Land-/sea-use change	Climate change
UNEA-1 Ministerial Declaration			
Resolution 1/8 - Ecosystem-based adaptation			
Resolution 2/6 - Supporting the Paris Agreement			
Resolution 2/8 - SCP			
Resolution 2/12 - Sustainable coral reef			
Resolution 2/13 - Sustainable management			
Resolution 2/16 -Mainstreaming of biodiversity			
Resolution 2/17 - Enhancing the work of UNEP			
UNEA-3 Ministerial outcome document			
Resolution 3/2 - Pollution mitigation			
Resolution 3/4 - Environment and health			
Resolution 3/5 - Investing in innovative solutions			
Resolution 3/6 - Managing soil pollution			
UNEA-4 Ministerial Outcome Document			
Resolution 4/1 - Innovative pathways to SCP			
Resolution 4/10 - Innovation on biodiversity			
Resolution 4/12 - Sustainable management			
Resolution 4/13 - Sustainable coral reefs			
Resolution 4/16 - Conservation of peatlands			

ANALYSED DOCUMENTS	OTHER KEYWORDS			
	Food security, Production & Consumption/ Agriculture	Land-/sea-use Environment/ Biodiversity/ Ecosystems/ Forests	Policy coherence	Sustainable Consumption and Production
UNEA-1 Ministerial Declaration				
Resolution 1/8 - Ecosystem-based adaptation				

ANALYSED DOCUMENTS	OTHER KEYWORDS			
	Food security, Production & Consumption/ Agriculture	Land-/sea-use Environment/ Biodiversity/ Ecosystems/ Forests	Policy coherence	Sustainable Consumption and Produc-tion
Resolution 2/6 - Supporting the Paris Agreement				
Resolution 2/8 - SCP				
Resolution 2/12 - Sustainable coral reef				
Resolution 2/13 - Sustainable management				
Resolution 2/16 -Mainstreaming of biodiversity				
Resolution 2/17 - Enhancing the work of UNEP				
UNEA-3 Ministerial outcome document				
Resolution 3/2 - Pollution mitigation				
Resolution 3/4 - Environment and health				
Resolution 3/5 - Investing in innovative solutions				
Resolution 3/6 - Managing soil pollution				
UNEA-4 Ministerial Outcome Document				
Resolution 4/1 - Innovative pathways to SCP				
Resolution 4/10 - Innovation on biodiversity				
Resolution 4/12 - Sustainable management				
Resolution 4/13 - Sustainable coral reefs				
Resolution 4/16 - Conservation of peatlands				

UNEA-3 followed suit by considering SCP policies, such as promoting sustainable finance and circular economy, as preventive solutions 'to tackle pollution and improve health and the environment synergistically.'[128] In the Resolution 3/5, a wide array of benefits from SCP policies for accelerating the implementation of the SDGs were recognized, including 'enhancing the capacity of ecosystems.'[129]

The fourth session of UNEA fully focused on SCP through its overarching theme 'Innovative solutions for environmental challenges and sustainable consumption and production', its Ministerial declaration and the specific Resolution 4/1 on 'Innovative pathways to achieve sustainable consumption and production'. While recognizing that achieving SCP is an essential requirement for sustainable development, the Resolution focuses on the nexus of production and the efficient use and sustainable management of resources, and identifies several measures to achieve SCP, including regulation, education, awareness-raising, sustainable finance, economic tools, technical standards, product design, and provision of systems, services and information, public procurement and particularly the life-cycle approach.[130] It explicitly recognizes that 'resource management, climate, biodiversity, water and land use are interlinked, and that resources are at the centre of voluntary initiatives, policies and regulatory frameworks.'[131]

Throughout UNEA outcomes, governance aspects are emphasized in relation to addressing the drivers of climate change and biodiversity loss, which is fully consistent with the role of UNEA. This is probably also confirmed by the choice of theme for UNEA-5, expected to take place in February 2021: 'Strengthening Actions for Nature to Achieve the Sustainable Development Goals', which suggests growing attention to the role of natural ecosystems in achieving the SDGs. The fifth UNEA session could also provide an opportunity to more explicitly account for the SDG interactions, and potentially a renewed chance to address forest issues. For a complete overview of our analysis results, see Table 6.3.

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128 'Environment and health', UNEA Res.3/4 (2017).

129 'Investing in innovative environmental solutions for accelerating the implementation of the Sustainable Development Goals', UNEA Res. 3/5 (2017).

130 'Innovative pathways to achieve sustainable consumption and production', UNEA Res. 4/1 (2017).

131 Ibid. at preamble.

6.5 Discussion and conclusions

In this paper, we have explored how the interactions between SDG 13 (climate action) and SDG 15 (halting terrestrial biodiversity loss) are addressed in the major international legal instruments related to those goals, the CBD and UNFCCC, as well as the UNEA as a complementary political process. In particular, we have focused on synergies, trade-offs and gaps in addressing the shared drivers of climate change and biodiversity loss.

Both CBD and UNFCCC address the direct drivers as well as some of the indirect drivers causing climate change and biodiversity loss, although with varying emphasis. The two Conventions make reference to each other, and the interactions between climate and biodiversity are acknowledged from multiple perspectives; that climate change can lead to biodiversity loss, but climate action could also affect biodiversity and ecosystems, and that biodiversity protection and enhancements are an important element in regulating the climate. Our findings echo previous analysis which has found that biodiversity is the environmental area with most references in climate-related agreements, while climate is the environmental area with the second most references in biodiversity agreements after the ocean issue area -although integration remains low across MEAs (Azizi et al., 2019).

For instance, co-benefits of activities that advance the goals of both Conventions, such as EbA, are well recognized in both Conventions and encouragement to take those benefits into account and enhance them is given. Similar measures are proposed, such as conservation and restoration to counter land-use change, national and sectoral mainstreaming, as well as environmental assessments. Both Conventions[132]also highlight the need to eliminate harmful incentives and address them through fiscal incentives. Nature-based solutions recently entered in the language of both Conventions, but the concept has not yet been defined under either Convention, leaving its potential to promote co-benefits and avoid trade-offs a question mark. The recently published IUCN Global Standard for Nature-based Solutions (IUCN, 2020) could help resolve this question.

While the CBD applies softer language (i.e. 'encourage'), the UNFCCC tends to be stricter when it comes to safeguards and considerations relative to land-related projects, making these a requirement, for instance, for funded projects. Moreover, the fact that LULUCF became a sector that must be accounted for in the developed countries' pledges and reporting is important and encourages synergies, although

132 'Updated assessment of progress towards selected Aichi Biodiversity Targets and options to accelerate progress', CBD Dec. 14/1 (2018), para. 2(q).

it does not apply to developing countries. The CBD mostly relies on voluntary action, whereas the UNFCCC had top-down targets that were legally-binding in the past, and now requires countries to submit plans that must be regularly enhanced in ambition and to report on progress. Binding commitments, or voluntary action combined with stronger monitoring, reporting and verification, has also been called for in the case of the CBD (UN, 2018). As a more innovative approach, the UNFCCC market mechanisms have brought the advantage of international cooperation to another level by offering countries the opportunity to support each other in meeting national targets (which were imposed in a top-down manner at the time that the market mechanisms were first introduced) with global implications. While the SDGs are comprehensive in their coverage of issues related to sustainable development, they are 'soft' law by nature (Persson et al., 2016). Hence, to ensure their implementation, it is essential that pertinent streams of international negotiations establish accountability mechanisms and provide the needed tools for action, as well as monitoring and evaluation (Bowen et al., 2017).

The trade-offs resulting from climate change mitigation affecting biodiversity loss have been broadly acknowledged and discussed within the two framework conventions, but important gaps remain. One concerns biofuels. IPCC scenarios for a maximum global warming of 2°C without overshoot typically rely on extensive use of carbon removal measures by 2100, including the use of bioenergy with carbon capture and storage (IPCC, 2014, 2018a). Yet, the impacts of extensive use of biofuels on biodiversity are not appropriately addressed in either of the Conventions. The CBD has indicated, under its work programme on agricultural biodiversity, that biofuel production and use should be sustainable in relation to biological diversity, but the topic has not played an important role in recent discussions and concrete or unified guidelines are not provided. The UNFCCC makes no mention of the issue in the documents assessed in this paper.

Thinking the other way around, trade-offs from biodiversity considerations for climate change mitigation have received even less attention. For instance, protected areas – a key tool promoted by the CBD – by default limit the designation of areas suitable for biofuel production and renewable energy generation. At the same time, scientific evidence supports territorial overlaps of natural carbon stocks (including soil carbon) and biodiversity hotspots, which could strengthen the argument for co-benefits provided by protected areas (Kapos et al., 2008). In this context, stronger emphasis on carbon storage or sequestration capacity of specific ecosystems provides an opportunity to strengthen synergies between the UNFCCC and CBD. So far, this perspective has only been substantially applied to forests while other carbon-rich ecosystems, like wetlands or marine and coastal ecosystems, have gained less attention.

Moreover, different timescales associated with measures that promise co-benefits, such as ecosystem restoration or biodiversity offsetting, may be a source for (temporary) trade-offs. It takes time for restored ecosystems to grow and develop their potential carbon-sink function, especially when biodiversity-promoting aspects such as natural regeneration or native species composition are prioritized (Pistorius & Kiff, 2018). If applied, 'no net loss' policies need to respect the mitigation hierarchy (avoid, minimize, restore, offset), with a clear prioritization of the first step (Ermgassen et al., 2019) – also to minimize potential trade-offs for emission reduction efforts.

An often cited gap in IEL concerns forests – that there is no international agreement on forests (Ebbesson, 2014; UN, 2018). The Rio Conference adopted a set of 'non-legally Binding Authoritative Statement' of forest principles, which emphasizes that the utilization of forests is subject to state sovereignty and therefore it has been argued that the principles do not form an adequate basis for a global regime (ibid.). Although forests are widely referred to in the CBD and UNFCCC, action in this area is mostly voluntary and nationally determined. While the two Conventions bring the global importance of forests into perspective as their transboundary and global effects are acknowledged, the UNFCCC emphasizes forests as a 'tool' in climate action, and the CBD focuses on the biodiversity values and indicators. A comprehensive approach, combining multiple ecological, social and economic values of forests, with legal implications, is missing. Academic literature on the global governance of forests is similarly fragmented as the regimes themselves, but it points two major trends: 'climatization' - the dominance of climate-related aspects in global policy discourses on forests - as well as a continued rejection of a global forest regime due to domestic influences (Singer & Giessen, 2017). The controversy of forests as a global common versus subject to national sovereignty is also reflected in the failed UNEA-4 resolution on deforestation presented by the EU and its Member States.

In addition, concrete measures towards sustainable agriculture that addresses both GHG emissions and biodiversity protection are mostly missing from the CBD and UNFCCC. Along similar lines, soil degradation (due to agricultural activities, peatland drying and as a result of climate change) could be better addressed, with positive impacts towards the objectives of both Conventions. UNEA has addressed land degradation and peatlands in Res. 4/16 (UNEA-4), making an explicit link to both biodiversity and climate change. However, as already noted, the attempt to address agricultural aspects in a specific resolution at UNEA-4 that targeted deforestation and agricultural commodity supply chains failed due to a lack of consensus.

As scientific advances are made in identifying context-specific trade-offs and co-benefits between climate change mitigation/adaptation through land-based actions and biodiversity-related goals, the challenge remains to account for them in international and national legal frameworks. The FAO has recently produced a strategy on mainstreaming biodiversity across agricultural sectors, with specific goals and activities to assist Member States and enhance capacities in mainstreaming biodiversity, particularly to seize the opportunities for creating synergies and in overcoming trade-offs they may face in pursuing multiple SDGs (FAO, 2020). While some of the key gap areas may be better addressed under other streams of international negotiations, such as the Convention to Combat Desertification, existing synergies and trade-offs call for integration across all pertinent international agreements. Streamlining of future mainstreaming and reporting obligations, and joint capacity-building across sectors and conventions represents an opportunity in this regard, particularly in the context of the Agenda 2030.

It is also important that increased recognition of co-benefits of biodiversity conservation and climate change mitigation actions does not lead to lower emission reductions in other sectors. Otherwise, conservation and restoration efforts risk becoming mere off-setting instruments, themselves undermined by the major indirect drivers related to the economy, consumption and production, and urbanization. Urbanization, infrastructure development and demographic drivers remain mostly unaddressed in the CBD and UNFCCC. As the world is becoming rapidly urbanized and the footprints of cities are growing, not accounting for the biodiversity and climate change impacts of those trends could undermine achieving both SDGs 13 and 15.

Both Conventions lack concrete measures on how to address the underlying economic drivers at the global level, but also nationally, particularly regarding consumption. International trade is only referred to by the UNFCCC in the sense of avoiding adverse effects of climate measures on it, but not as a driver. Concrete measures for SCP could be promoted more both at the national and the international levels. Even though SDG 12, the closest to SCP, presented the highest number of trade-offs with other SDGs in a previous analysis of SDG interactions, SDG 12 was also found to be the most synergistic SDG for SDG 15 and one of the best for SDG 13 (aside from SDGs 11 and 1), highlighting the importance of SCP in achieving SDGs 13 and 15 (Pradhan et al., 2017b). Within the SCP framework, economic diversification towards lower resource intensity, circular economy, and production standards would support both Conventions by reducing footprints of products and of gross domestic product (GDP) per se.

UNEA has made significant advances in these discussions. While explicit references to interactions between climate change and biodiversity loss are sporadic at best in the UNEA resolutions, and they do not yet seem to represent many new openings on better accounting for interactions in international cooperation, the strongest potential for addressing widely synergistic action concerns the UNEA focus on SCP. UNEA has emphasized SCP as an essential tool to achieve sustainable development, with potential for improving sustainability in various domains and supporting the achievement of different SDGs beyond SDG 12. UNEA has also explicitly established the nexus between production and the efficient use and sustainable management of resources, acknowledging that resource management, climate, biodiversity, water and land use are interlinked. In addition to urging governments to accelerate and support efforts in making production and consumption more sustainable, UNEA has emphasized the essential role of other stakeholders in the implementation of SCP policies, including the business and financial sector.

Hence, following up on resolutions that have consolidated attention to SCP in the international context of UNEA could present an opportunity to achieve widely synergistic benefits for sustainable development, including SDGs 13 and 15. Yet, other important gaps in the IEL persist, notably in addressing deforestation, agricultural drivers and specific fragile but carbon and biodiversity-rich ecosystems such as wetlands and coastal ecosystems (as well as marine ecosystems and SDG 14). International fora such as UNEA could play an important role in addressing those gaps and helping to harness synergies by building the necessary discussion and international consensus towards more legally binding instruments, with the ultimate aim of reducing IEL fragmentation. Improved coordination between UNEA and the CBD and UNFCCC would be also beneficial for strengthening policy coherence and enhancing SDG implementation at regional and national levels.

The Maya civilization likely collapsed due to environmental degradation and climate change. Photo taken in Tulum, Mexico, 2011

Author reflecting on humanity's current environmental impacts and the resulting climate change. Photo taken in Ek' Balam, Mexico, 2021.

7

Enablers of ambitious climate action: Synthesis and recommendations

7.1 Introduction

In my thesis, I investigated how ambitions on climate-change actions can be raised in view of the ever-growing urgency to address the anthropogenic climate change. More concretely, I analysed the effects of four major enablers of ambitious climate action: key moments in international climate negotiations (Chapters 2 and 3); country contexts in view of responsibility and capability (Chapters 2 and 5); international climate finance (Chapters 3 and 4); and policy coherence for the joint implementation of the Paris Agreement and the 2030 Agenda for sustainable development (Chapters 4, 5 and 6). Concerning the last enabler, four levels of policy coherence were addressed: coherence between the international and the national contexts (Chapters 2 and 5); coherence between social, economic and environmental dimensions of development (Chapter 5); coherence between diverse sources of finance (Chapter 4); and coherence between international agendas (Chapter 6). While this is not a complete list of climate-action enablers, it covers some of the most important ones. Some enablers that fell outside the scope of my thesis, are, for example, coordination among different types of stakeholders and private sector climate finance.

To investigate the aforementioned key enablers of climate-action ambition, my thesis sought to answer five key research questions (RQs), one in each core chapter:

RQ1 What are the observed changes in adopting national climate-change mitigation strategies, legislation, greenhouse-gas (GHG) emissions targets, renewable energy targets and energy-efficiency targets over the period 2007-2017 and how are these changes correlated with key moments in international climate negotiations? (Chapter 2)

RQ2 Are measures of capability and responsibility correlated with the ambition of GHG-emission-reduction targets put forward by countries in their Nationally Determined Contributions? (Chapter 3)

RQ3 Has climate-related finance historically targeted priority areas described in developing countries' Nationally Determined Contributions and has this finance been better correlated after the Paris Agreement? (Chapter 4)

RQ4 What are the effects of climate-change mitigation measures on the Sustainable Development Goals and how can these be addressed to minimize trade-offs and maximize synergies between the Paris Agreement and Agenda 2030? (Chapter 5)

RQ5 How do the international Conventions on Climate Change (UNFCCC) and on Biological Diversity (CBD) address common drivers of climate change and biodiversity loss and how could these international agendas be further integrated to enhance co-benefits and reduce trade-offs between their measures? (Chapter 6)

In this chapter, I discuss key findings and conclusions of my thesis in the context of existing literature and current international climate negotiations. In that sense, this chapter synthesizes my (and my collaborators) findings of assessed climate enablers and answers the five RQs. Moreover, I seek to provide policy recommendations to support more ambitious climate action, both in the international and domestic processes. My recommendations address in particular international negotiators under the UNFCCC, the 2030 Agenda (in particular, the UN Department of Economic and Social Affairs), the CBD and other relevant strands of climate-relevant international negotiations, as well as policy makers that operate nationally, sub-nationally and locally. Additionally, these recommendations are likely also relevant to all other UN agencies and international organizations that are involved in climate action and sustainable development, as well as financial institutions, civil society and the private sector.

Table 7.1 Structure of this chapter and how it synthesizes climate action ambition enablers analysed in Chapters 2-6.

Enablers of climate ambition	International cooperation	Country context	International climate finance	Policy coherence
Chapter 2	Sections 7.1 & 7.4.1			
Chapter 3	Section 7.1	Section 7.2	Section 7.3	
Chapter 4			Section 7.3	Section 7.4.3
Chapter 5		Section 7.2		Sections 7.4.1&2
Chapter 6				Section 7.4.4

Sections 7.1 to 7.4 discuss the findings of Chapters 2 to 6 along the four major enablers of ambitious climate action and provide future research recommendations to tackle remaining research and policy gaps and limitations (structured as in Table 7.1). Moreover, at the end of each section, I provide bulleted lists of policy recommendations for pertinent international and national actors. These recommendations seek to guide these actors on how to use our findings to leverage assessed enablers towards stronger climate action. Section 6.6 brings these findings together, concretely answers the RQs and discusses how the major enablers of ambitious climate action could be leveraged nationally and internationally. In particular, this last section considers the current processes under the Paris Agreement and the 2030 Agenda.

7.2 The role of international climate negotiations

International climate negotiations have been conducted annually for almost three decades since the adoption of the UNFCCC in 1992. The objective of these negotiations is to achieve “stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system“ (UNFCCC, 1992, Art. 2). Moreover, it requests parties to strengthen resilience and enhance adaptation against the effects of climate change, and to support developing countries to take climate adaptation and mitigation action.

In pursuit of these objectives, global climate governance has approached the climate challenge from various perspectives. Hence, it evolved from a focus on top-down internationally agreed targets for developed countries alone, to a bottom-up approach whereby all countries are encouraged to present their desired contributions towards a pre-set international goal of keeping global temperature increase well below 2°C (Höhne et al., 2017). The Kyoto Protocol in 1997 set internationally agreed GHG emissions reduction targets for developed (i.e. Annex I) countries with an implementation period of 2005-2012 and an extension to 2012-2020. At the 15th Conference of Parties (COP) in Copenhagen 2009, countries agreed on seeking approaches that would involve both developed and developing countries to address dangerous anthropogenic climate change. High GHG emitting countries like China and India, as well as other developing countries of lower GHG emissions put forward voluntary GHG emissions targets and prepared climate strategies. Funding and support became available to developing countries that provided Nationally Appropriate Mitigation Actions and National Adaptation Plans. Finally, with the Paris Agreement in 2015, countries achieved a bottom-up approach that engages all countries in climate-mitigation action and that is propelled forward by a cyclical process designed to continuously ramp up ambition.

Nevertheless, despite extensive international discussions and a broader inclusion of parties and actors, GHG emissions continue to grow and climate-change impacts are felt around the world. Despite recent important events, such as the new NDC of the United States, currently the second largest GHG emitter after China, countries that are parties to the Paris Agreement, are together still failing to achieve the international target of keeping global temperature well below 2°C (Climate Action Tracker, 2021).

Given this slow progress in curbing GHG emissions, the effectiveness of international climate cooperation to bring about national change can be questioned. To address this knowledge gap, I analysed the worldwide effects of international negotiations in two ways. First, I looked at the adoption of national GHG emissions reduction targets, renewable energy targets, energy efficiency targets and national strategies or legislation during the period 2007-2017 (RQ1; Chapter 2). Second, I analysed countries' NDCs under the Paris Agreement and the updated GHG emissions reduction targets (RQ2; Chapter 3).

We found that various developments in the global climate-change governance approaches have had a visible effect on countries' adoption of national climate targets, strategies and legislation, and have broadened the involvement of UNFCCC parties over time (Chapter 2, RQ1). First, we found that the coverage of national strategies and legislation grew at a much faster pace in the years prior to and immediately after the Copenhagen Accord with larger GHG-emitting countries taking the lead in earlier years. Yet, the rate of country and emissions coverage has saturated in recent years. Second, while developed countries had GHG-emissions reductions in place since the start of the Kyoto Protocol, very few other countries adopted such targets in subsequent years. This has seen a dramatic change in the run-up to the Paris Agreement in 2015 when the share of countries that set a GHG-reduction target jumped from a quarter to almost three quarters, followed by another stagnation. More renewable energy targets have been adopted at a rapid steady pace in the studied period and they were taken up by most countries that have a GHG-emissions target. On the other hand, energy-efficiency targets have seen a fast increase prior to 2006, followed by a slow steady growth that led to a coverage of only one third of all countries in 2017. However, while development in renewable and energy-efficiency targets are likely influenced by the general international climate-action momentum, they also reflect the rapid decrease in the cost of renewable energy production and the still higher costs and limits of energy-efficiency improvements.

While the Paris Agreement was highly successful in boosting the number of countries with GHG emission targets, the cyclical process of ramping up ambition has shown, to date, somewhat mixed results (Chapter 3, RQ1). As countries GHG-emissions reductions do not yet add up to keep the global temperature increase well below 2°C and ideally at no more than 1.5°C, more ambition was expected in the updated NDCs prior to the Paris Agreement implementation phase starting in 2020. However, even though countries are obliged to continuously increase ambition through the Paris Agreement, we found that less than half of the updated NDCs by the end of 2020 do so, and only a few provide their first unconditional or conditional GHG-emissions reduction targets. In 2020 updated NDCs, most countries even went in the opposite direction and either pledged higher GHG emissions in 2030 than in their initial NDC or kept their targets unchanged. In the case of countries that increase GHG emissions by 2030, a change in methodological approaches in the determination of GHG-emissions projections under a Business-as-Usual (BAU) scenario led to higher expected emissions in the future.

These findings raise concerns regarding the ambition of future targets under the Paris Agreement and the ability to monitor progress of target achievement. They highlight the importance of clear international guidelines and standards on target formats. As shown in Chapter 3 and in line with the literature, targets defined relative to BAU emissions tend to lead to lower GHG emissions relative to other target formats, such as emissions reductions relative to a base year. Moreover, the lack of a standard target format poses challenges to comparing targets and makes the application of ambition raising mechanisms based on peer pressure and soft reciprocity difficult. As the Paris Agreement is based on bottom-up voluntary climate action, these mechanisms are essential to ensure its success.

I focused on the adoption of national climate-relevant targets and climate strategies and legislation, but the achievement of these targets and strategies rests on the further adoption and implementation of adequate national measures. Target setting is essential to create a guiding pull for climate action and it reflects political will. Moreover, national climate strategies and, in particular, legislation are roadmaps to achieve these targets and are key to successfully achieving the targets. Yet, the actual implementation of these targets through adequate national interventions is what can ensure the success of national and international climate goals. Such interventions are concrete indicators of where countries are headed in terms of short- and long-term emissions and the pace of their low-carbon or carbon-neutral transitions. Similar to our findings concerning national strategies adoption (Chapter 2), the literature shows an increase in the uptake of climate-relevant policies around the world (e.g. Averchenkova et al., 2017) and in major emitting countries (Nascimiento et al., 2021) over the years. However, current measures are insufficient to implement the NDC targets (Roelfsema et al., 2020) and global emissions could be further reduced through a wider adoption of good practice measures (Roelfsema et al., 2018). While targets set the vision, a clear understanding of what it takes to reach that target, leveraging the involvement of actors and stakeholders, and an increased capacity to do so in developing countries are key (Upadhyaya et al., 2021). Future research, and in particular research that focused on target-achievement progress, should go beyond the adoption of climate-relevant targets in national strategies. Such research could assess the coverage, stringency and implementation rates of climate-relevant measures across key sectors.

To conclude, I showed that international climate processes have played an important role in boosting climate ambitions worldwide and continue to do so. To date, the vast majority of countries have implemented GHG-emissions targets and national climate strategies, and many continue to raise their ambition. Yet, while the Paris Agreement increased the number of countries engaged in climate action, its bottom-up and nationally determined approach runs the risk of low implementation. To avoid this, climate pledges must be substantiated by adequate standards, guidelines and processes that enable mechanisms for exchange, ambition raising and mutual learning. The real effect of international climate negotiations on the ground is subject to further study and such effects are likely strongly influenced by country contexts, as discussed in the following section. Nevertheless, the influence of key international climate moments is clear and momentum could continue to be generated, for example, in the run up to each 5-year global stocktake and NDC submission deadlines.

Recommendations to increase the impact of international negotiations:

- Relevant UN agencies and climate negotiators should ensure a continued momentum for climate action through planned international events that have the potential to bring countries and stakeholders together with the common goal to reduce GHG emissions; and
- UNFCCC processes should further standardize target-setting requirements for all countries (avoiding formats relative to BAU scenarios) to enable comparison, improve monitoring of progress, and ensure a cyclical increase in ambition while avoiding slide-backs.

7.3 The role of country contexts in setting emissions reduction targets

While climate change is a global issue and GHG emissions from anywhere have an effect everywhere, international climate negotiations have recognized differences in development between countries from the very beginning. In that sense, the principle of ‘common but differentiated responsibilities and respective capabilities’ was enshrined in the Framework Convention on Climate Change of 1992. This principle reflects the differences between developed and developing countries with regard to their historical GHG emissions and the ability to tackle climate change. It recognizes the need and the right of developing countries to continue to develop and to increase their GHG emissions in the short-term along their pathway of economic growth. As a result, until the Copenhagen Accord in 2009, climate action was expected only from developed countries (i.e. Annex-I countries). However, as GHG emissions increased rapidly around the world and some developing countries surpassed developed countries in their annual emissions, recent international climate negotiations have sought to engage all UNFCCC parties (countries) in climate action. Both developed and developing countries are now putting forward contributions under the Paris Agreement but they are subject to differentiated requirements, for example, with regard to progress reporting and coverage of GHG emissions sectors. Developing countries themselves use a language of differentiation in their NDCs (Pauw et al., 2019).

Beyond the binary divide of developed versus developing countries, a variety of relevant development contexts and a broad distribution of countries across the scales of respective development indicators likely influence political will on climate action. In their NDCs, countries argue for the fairness of their climate-action pledges mainly based on their current and historical GHG emissions and economic development levels (Winkler et al., 2018). Yet, other important drivers of climate ambition and socio-economic transformation, such as policy and technological innovation and leadership, should also be considered (Biedenkopf et al., 2017; Schwerhoff, 2016; Victor et al., 2019). Being able to identify countries that are high performers of climate action relative to other countries of similar contexts, can support mutual learning and a more rapid diffusion of policy and technological innovations. Moreover, being able to compare countries pledges relative to their peers of similar development contexts is essential to the mechanisms of mutual learning, peer pressure and soft reciprocity of the Paris Agreement.

In Chapter 3, we analysed the correlation between GHG emissions reduction levels pledged in countries' NDCs and a set of key development indicators that represent different country contexts: Gross Domestic Product (GDP) per capita; historical and annual GHG per capita; GHG per GDP; trends in GHG per capita and GDP per capita; and fossil fuel exports (answering RQ2). The aim was to determine how specific development contexts influence the level of GHG emissions reductions; how countries position themselves among others of similar contexts; and to allow for comparison and identification of role models within specific country groups. The selected development indicators closely reflect most invoked fairness principles in the NDCs and additionally indicate countries' economic dependence on fossil fuels. This makes them highly relevant to the comparison of country GHG emissions reductions targets based on country contexts.

We found that the level of pledged GHG per capita emissions reductions is correlated to countries' GDP per capita and (historical) GHG per capita. Almost all countries' with above-average GDP per capita aim to reduce their GHG per capita emissions by 2030 relative to 2010. Exceptions to this rule are Singapore, Saudi Arabia and Russia, which are all countries with relatively high fossil fuel exports as a share of GDP. This suggests that dependence on fossil fuel exports is also an indicator that influences pledged GHG emissions reductions. Nevertheless, there are also notable exceptions such as Norway and Kazakhstan, who have high shares of fossil fuel exports but aim to reduce their GHG per capita by 2030 relative to 2010. In general, high levels of GHG per GDP and fossil fuel exports highlight the need for deeper economic and technological transitions and innovation in respective countries. Importantly, we found that some developing countries have high conditional GHG-emissions reductions relative to 2010, despite low GDP per capita and GHG per capita. This highlights the importance of adequately targeted international climate finance to boost climate action, which is further discussed in the next section.

In Chapter 5, we also showed that country contexts are essential factors to relate climate and sustainable development and explain how these interlinkages play out nationally and locally (as an outcome of RQ4). In that sense, the national and local context could determine whether climate-mitigation measures lead to positive or negative effects on other SDGs. We showed that the location of implementing measures and the choice of technology and policy approaches are key determinants of the occurrence and magnitude of many of these climate-SDG effects. Availability of non-renewable natural resources locally and nationally is an additional determinant of domestic effects. For instance, strong large-scale biofuel production measures in especially food insecure areas could further exacerbate lack of food access. Yet, use of any type of renewable resources could support countries that are highly dependent on energy imports, to boost both energy security, and the economy and employment. Nevertheless, phasing-out fossil fuels in countries with high employment in this area can pose a risk of increased unemployment, if an adequate transition is not set in place for the affected groups.

Future research could take this analysis further by using sector-specific and policy implementation climate indicators. Due to their universality and simplicity, countries' GHG-emissions targets are a key first-step indicator of political will for climate action and can allow for comparison among similar countries. Nonetheless, as indicated in the previous section, an understanding of more specific climate-action indicators, including policies and implementation, is needed. Moreover, given the differences between developed and developing countries, normalization of GHG-emissions targets is challenging. In Chapter 3, we normalize relative to the year 2010, as both developed and developing countries started to report on their climate actions after the Copenhagen Accord, and a more inclusive future approach was made clear. However, other base years for normalization could be explored.

Finally, while we analysed key development-related indicators that immediately reflect countries' most invoked fairness principles, a broader perspective on country context could provide additional insights and better explain outliers. These should include not only a broader variety of indicators but also analyses based on compound indicators to address the interrelations. In the following two sections we show, for example, that countries have very different development priorities across the SDGs. This is also key in studying how expected effects of the country context dimensions that are discussed in Chapter 5, play out on the ground.

As the Paris Agreement lacks a mechanism to impose specific GHG-emissions reductions on countries, ensuring that bottom-up mechanisms based on mutual learning, soft reciprocity and peer pressure have a real effect is essential. Being able to group countries based on climate-relevant development indicators and GHG-emissions targets in a comparable fashion can enable the identification of high performers and allow for soft reciprocity and exchange on technological and policy innovations to emerge. Moreover, it could support the global stocktake process with needed information, inspire ambition and identify needed international support for conditional targets in ambitious developing countries. Additionally, identifying adequate policy options that take into account country contexts and are able to address trade-offs while maximizing co-benefits can increase climate action acceptability and political will.

Recommendations to enable stronger climate action in varied contexts:

- UNFCCC processes should include comparison of countries' GHG emissions targets through the lens of a variety of relevant development indicators to enable peer-pressure and soft-reciprocity dynamics, and to identify role-models among specific country groups that could enhance mutual-learning on technological and policy innovation; and

- Researchers and policy makers should seek to Identify other important development indicators and country contexts that influence the levels of GHG emissions reductions and to determine how these could be addressed to enhance climate action ambition.

7.4 The role of climate finance as a booster of national capability

As suggested in the previous sections, developed and developing countries in the UNFCCC processes are strongly differentiated concerning the expected climate-action ambition and international support from each side. With the adoption of the UNFCCC, developed countries were expected to act on climate change and not only within their domestic borders. Additionally, developed countries (and more recently countries with emerging economies) are expected to support developing countries through capacity building and international transfers of finance and technology. Through the Copenhagen Accord, international support for developing countries became more concrete with the establishment of the Green Climate Fund and the adoption of a climate finance target of USD 100 billion mobilized annually by 2020. This target was now extended to 2025 and a new target will continue to be negotiated at the 26th Conference of Parties in Glasgow at the end of 2021.

Although international climate financial flows remain below the Copenhagen target to date and reporting standards are still highly debated (Roberts et al., 2021), the achievement of the Paris Agreement temperature goal is dependent on it. As indicated, countries' current NDC pledges are still inadequate to meet this goal (Climate Action Tracker, 2021; Höhne et al., 2020) and their full implementation is also not certain. Boosting conditional GHG reduction targets could further support the achievement of the Paris Agreement, but existing NDC conditional climate action requests already exceeds the climate finance target under the Copenhagen Accord (Pauw et al., 2020). Failing to provide the needed support for climate action could undermine the Paris Agreement, but it could also miss opportunities to reduce GHG emissions around the world (possibly more cheaply) while supporting developing countries to grow in a sustainable fashion. Scaling up climate finance globally is essential, but this should also reflect countries' climate and development needs as stated in the NDCs (UNEP, 2018).

In Chapters 3 and 4, we analysed the distribution of climate-relevant Official Development Assistance (ODA) of the Development Assistance Committee relative to recipients' requests (answering both RQ2 and RQ3 from the perspective of countries capability and finance coherence, respectively). First, we found that past climate-relevant ODA and countries' pledged conditional GHG/cap emissions reduction are not correlated. Second, we found that this finance mainly focused on mitigation and did not match developing countries' higher interest in adaptation measures, although the balance between adaptation and mitigation has improved in recent years. Both the Copenhagen Accord and the Paris Agreement requested a balanced distribution of climate finance for adaptation and mitigation action.

Our results show that the vast majority of climate-relevant ODA was distributed to lower- and upper- middle income countries (i.e. half and a third respectively) between 2010-2018. However, in our analysis of countries' pledged conditional GHG per capita reductions by 2030 relative to 2010, we found that low income countries had targets comparable to those of the middle income countries. Moreover, these low income countries also put forward a comparable share of climate activities in their NDCs. Both of these results indicate a high interest for climate action in low income countries, despite low international support to date. Hence, future climate finance could target these countries to bank on political will and to further support development. Nonetheless, middle income countries likely offered more opportunities to leverage additional finance, for instance, through the private sector. Moreover, middle income countries likely assumed that they will not receive as much international finance in the future, as they further develop economically and therefore did not pledge higher conditional targets than the low-income countries.

In addition to the distribution of climate-relevant finance across countries, the distribution across development sectors and whether these match recipient countries' needs and priorities is also important. For instance, we found that developing countries put forward more climate activities that address adaptation or both adaptation and mitigation in their NDCs (i.e. 49% and 12% respectively). On the other hand, climate-relevant ODA finance and transactions have focused predominantly on mitigation during 2010-2015 (i.e. above 60%) and have become only slight more balanced relative to adaptation in recent years. Decisions under the UNFCCC have emphasized a balance between the two areas of climate action. The distribution of ODA across SDG-relevant development areas has not become better correlated with countries NDC activities post-Paris (further discussed in Section 7.4.3). To enhance ownership and the effectiveness and acceptability of development cooperation projects, donors need to better tailor their climate-relevant finance distribution to respond to developing countries' needs and interests (in line with the Paris Declaration on Aid Effectiveness from 2005). While conditional climate action provides opportunities for higher ambitions, it requires adequate donor-recipient cooperation.

What counts as climate finance and how large climate financial flows are remain contested issues. ODA only represents a share of climate financial flows, but it remains an important source, including through its widely used methodology (UNFCCC SCF, 2018; Romain Weikmans & Roberts, 2019). Nonetheless, over-reporting and a lack of clear guidelines of what constitutes climate finance and how to add up finance provided through various instruments (e.g. loans versus Grants) remain a real concern. An important step in the UNFCCC process will be to find consensus and provide clear guidelines on climate finance reporting (c.f. Roberts et al., 2021). In particular, climate finance for adaptation has been difficult to measure due to questions of additionality (Weiler et al., 2018). Such improvements in standards and reporting will enable more insightful research on climate finance in the future and a better overview of the level of achievement of the finance target.

To conclude, the importance of international climate-finance has been highlighted by the large number of conditional climate pledges of countries under the Paris Agreement, but aligning donors and recipient perspectives and balancing adaptation and mitigation finance remains challenging. Hence, improved cooperation is likely needed to increase aid ownership and effectiveness, in line with the 2005 Aid Effectiveness Paris Declaration that was reiterated in Busan 2011. Moreover, both future research and policy improvements in this area are dependent on adequate reporting standards and transparency. As countries are now discussing a new climate-finance target, clarification on what counts as climate finance is essential, along with a roadmap to improve the adaptation and mitigation balance. The post-2025 finance target must reflect the urgency to tackle dangerous anthropogenic climate change and the potential of conditional targets to further limit GHG emissions worldwide. Importantly, how post-COVID-19 recovery finance will be used has a decisive role in the achievement of the Paris Agreement, as it may seize or close this final window of opportunity.

Recommendations to boost climate action through climate finance

- Donors should target developing countries that show high willingness to conditionally reduce GHG/cap emissions, while taking into account which countries can benefit most from these development opportunities and which can mobilize additional finance; and
- Donors and recipients should develop a joint understanding of the reasons behind the adaptation and mitigation differences in climate-relevant ODA relative to recipient countries’ NDC activities and find the best way to move forward.

7.5 The role of climate and sustainable development policy coherence

Climate change and sustainable development are intricately interlinked. First, climate change has a variety of negative effects on a broad range of socio-economic and environmental areas, such as food and water security or poverty and inequality alleviation. This makes development more challenging. Second, the deep transformations required to tackle climate change touch on all economic sectors with positive and negative effects on various development areas (Roy et al., 2018). Third, sustainable development policy intervention choices have the potential to either increase or decrease GHG emissions in the short- and long-run, and to increase or decrease resilience to climate change (UNEP, 2016).

Hence, climate action ambition is tightly linked to development priorities in the short- and long-term, and it is dependent on a clear understanding of the rich opportunities and challenges of climate actions by decision makers. For instance, increasing energy access through the use of fossil fuels would increase GHG emissions and lock countries into emissions-intensive infrastructures. On the other hand, using renewable energy resources would reduce emissions and bring multiple benefits such as improved air quality. Nonetheless, renewables could also have negative effects such as increased food prices (i.e. in the case of biofuels) or communities' resettlement for hydropower reservoirs. Such effects depend on the type of renewable sources, location and mode of implementation. Similarly, expanding settlements in flood-prone areas would expose a larger number of people to the effects of climate change, especially if no adaptation measures are taken.

The interlinkages between climate change and areas of sustainable development have been part of the international debate for a long time. They were acknowledged in the UNFCCC and they are now strongly emphasized in the most recent international agreements on climate and sustainable development, the Paris Agreement and the 2030 Agenda, both adopted in 2015. In that regard, the Paris Agreement emphasizes "the intrinsic relationship that climate change actions, responses and impacts have with equitable access to sustainable development and eradication of poverty" (Paris Agreement, 2015, p. 1). Similarly, the 2030 Agenda defines climate change as one of its seventeen SDGs (i.e. SDG 13) and indicates that "Climate change is one of the greatest challenges of our time and its adverse impacts undermine the ability of all countries to achieve sustainable development."(2030 Agenda, 2015, para. 14). Despite strong international recognition of these interlinkages, countries are still struggling to adequately integrate climate and the SDGs and to boost ambition in view of meeting multiple objectives.

In that sense, integrating and aligning climate and development actions to ensure policy coherence is key to the transformation to sustainability. To emphasize its importance, the 2030 Agenda made 'policy coherence' an SDG target in itself – "SDG 17.14 Enhance policy coherence for sustainable development". In my thesis, policy coherence for sustainable development is defined as an "approach and policy tool to systematically integrate the social, economic and environmental dimensions of sustainable development at all stages of domestic and international policy making" (OECD, 2018, p. 83). This integration occurs at five complementary levels and it seeks to maximize synergies and minimize trade-offs between the three different dimensions and respective SDG goals at each level. The five complementary levels defined by the OECD are: coherence between global and national context; coherence among international agendas and processes; coherence between social, economic, and environmental policies; coherence between different sources of finance; and coherence between diverse actions of multiple actors and stakeholders.

My thesis addressed all key levels of policy coherence defined by the OECD, mentioned above, except for policy coherence between diverse actors. The focus of Chapters 4, 5 and 6 of this thesis was particularly on horizontal coherence (i.e. coherence across different sectors and policy areas), rather than vertical coherence (i.e. coherence across different governance levels). In the following sections, I present how the policy coherence levels were addressed by individual chapters.

7.5.1 Coherence between global and national contexts

This level of coherence requires that national and sub-national policies are aligned with internationally agreed goals and measures, in this case for climate and the SDGs. In my thesis, we analysed national policies in two chapters. In Chapter 2, we analysed the adoption of overarching national climate-change strategies and legislation between 2007 and 2017. There, we found that the share of UN countries with such strategies or laws has grown steadily, from approximately one fifth to half from the start to the end of the period. Most high GHG-emitting countries adopted such strategies prior to the Copenhagen Accord in 2009. Nonetheless, only a quarter of all countries adopted climate legislation. In Chapter 5, we analysed existing climate mitigation measures in the G20 countries. We found that these countries tend to more frequently adopt climate strategies that are additionally supporting a variety of SDGs.

We observe that counties increasingly adopt national policies that support the implementation of international goals, and in particular those countries that have a stronger historical responsibility. Yet, an extensive analysis of existing national climate and sustainable development policies fell outside the scope of my thesis. In depth research on the uptake of national policies to implement the Paris Agreement and the SDGs and the stringency and effects of these policies could provide further insights on coherence between global and national contexts and the likelihood of internationally pledged targets to be implemented nationally.

Recommendation:

- National and sub-national policy makers should implement domestic policies, such as national strategies, to support the implementation of international pledges on climate action.

7.5.2 Coherence between economic, social and environmental policies

Horizontal policy coherence is particularly important for the implementation of the Paris Agreement and the 2030 Agenda and not only internationally but also nationally. Given the deep socio-economic and environmental transformations and ambitious timelines of these two agendas, maximizing synergies and minimizing trade-offs between different areas of action is essential to increase the likelihood of reaching the global SDGs.

In Chapter 5, we analysed the effects of climate change mitigation measures on the SDGs (first part of RQ4). We showed that climate change mitigation measures have implications for the social, economic and environmental dimensions of 15 out of 17 SDGs. The remaining SDGs, SDG 16 and 17, are focused on the mode of implementation and, hence, also indirectly relevant to climate action. While most effects are positive, negative effects can also occur. Overall, SDGs 6 (water), 7 (energy), 8 (economic growth and jobs), 9 (industry and infrastructure), 11 (cities) and 12 (sustainable consumption and production) have the largest number of targets that are positively or negatively affected by most types of climate-mitigation measures. Energy-efficiency improvements, transition to non-biomass renewable energy and reduction of energy demand represent measures with the highest number of co-benefits for all SDGs. On the other hand, carbon capture and storage applied to fossil fuels or to biomass energy production risks the highest number of negative effects across the SDGs, followed by gas and nuclear energy.

Moreover, in the same chapter, we indicated potential ways to enhance coherence between the two agendas by means of policy design and policy mixes to enhance synergies and to reduce trade-offs (second part of RQ4). We showed that the location, where a measure is implemented, and the choice of technology and policy approaches are key determinants to the occurrence and magnitude of many of these effects. Availability of non-renewable natural resources locally and nationally is an additional determinant of domestic effects. Trade-offs, in particular, can be addressed both through the design of a policy and through the adoption of complementary policies in affected areas. For instance, the risk of food insecurity and biodiversity loss due to biofuel production could be addressed through specific standards and limits on the approach and location of relevant cropping systems. This can be designed into the enabling policy. Hence, an incentivizing policy could additionally impose standards such as lower use of fertilizer, ensuring a certain distance from biodiversity-rich ecosystems or an interdiction of biofuel plantations in (highly fertile) areas of key importance for food security. On the other hand, complementary policies could regulate the price of agricultural land to avoid rapid increase in food prices and could incentivize use of raw biofuel material from small-scale farmers to support their incomes and reduce large-scale production. In general, mainstreaming and integrating climate change in all relevant policy areas and vice versa will be essential for goal coherence.

Finally, in Chapter 5, we also analyse the choice of climate-change mitigation measures of the G20 countries to identify national effects of climate mitigation effects on the SDGs. We find that these countries choose to address the global challenge of climate change through implementation of national policies that are generally more beneficial across the development spectrum. Hence, the G20 countries more frequently adopt measures such as energy efficiency improvements and non-biomass renewable electricity production, rather than energy pricing and biomass use. The implications of climate-change mitigation measures on other SDGs influence countries' ambitions with regard to GHG-emissions reduction. Socio-economic implications, in particular, have often been brought to the fore as key barriers to climate-change mitigation. As we showed, most climate-change mitigation measures predominantly positively affect many SDGs, making them appealing when all dimensions of the 2030 Agenda are considered. Yet, existing negative effects are the likely culprits of slow progress on climate action nationally and internationally.

Identifying climate measures that are coherent with national contexts and priorities when implementing the global agendas and tackling trade-offs, is essential to enable more ambitious climate actions. While our research provides a comprehensive overview of climate-mitigation measures on the SDGs, it further needs to be complemented with a good overview of the effects of other SDGs on climate change. Moreover, we highlighted which country contexts play a role in the occurrence and magnitude of effects and suggested several potential approaches to enhance synergies and address trade-offs. Yet, more in-depth research on such options and country applications is urgently needed. Expanding our understanding of various goals interactions and what are good practices for joint implementation is essential to the international and the national policy processes. Internationally, countries could reflect on the interlinkages with other SDGs in their NDCs and mainstream climate change in their Voluntary National Reports and the National Sustainable Development Strategies for the 2030 Agenda implementation.

Recommendations:

- Policy makers should seek to gain a better understanding of the interlinkages between climate and the SDGs to ensure policy coherence for social, economic and environmental objectives; and.
- Policy makers should consider national and local context dimensions that influence effects of climate policies on the SDGs in policy design and policy mixes to minimize negative effects and maximize positive effects.

7.5.3 Coherence between different sources of finance

Mobilizing sufficient finance is one of the major barriers to achieve the Paris Agreement and the 2030 Agenda goals (Pauw et al., 2020; UN, 2020). While climate-change finance has increased substantially in recent years, it continues to be surpassed by fossil fuel investments (UN, 2020). Moreover, key global players such as the G20 countries, responded to the COVID-19 crisis with high investments in fossil fuels that may undo the little progress made to date to phase out fossil fuels (Geddes et al., 2020). In view of the strong interlinkages between climate change and the SDGs, coherence between development and climate spending is essential to ensure a more efficient use of the limited available financial resources. Additionally, donors provision of finance can build more ownership if matched with recipient needs and priorities and can enhance climate action ambition through improved political acceptance.

In Chapter 4, we link the 2030 Agenda and the Paris Agreement through a common international financing source to implement the two agendas in developing countries, namely climate-relevant ODA. Historically, this has supported countries on their development objectives. Nonetheless, banking on the co-benefits of climate action to development and the interest of donors to reduce GHG emissions for their own and the global common good, ODA became a major source of finance for climate change. To further understand how this finance responds to countries needs and priorities, in Chapter 4 we assessed climate-related ODA relative to NDC activities, based on contributions to the SDGs.

Our analysis in Chapter 4 showed that SDG priorities expressed in countries NDCs are matched by the SDG focus of climate-relevant ODA in recent years before and after the Paris Agreement (answering RQ3). In that sense, both recipient countries' NDC activities and climate finance overall show a stronger focus on SDGs 7 (energy), 11 (cities), 2 (food security) and 15 (life on land). This is true not only where climate is the 'principal objective' of a financial transaction, but also when it represents only a 'component' or a 'significant objective'. Yet, no improvement in coherence is observed between the periods before and after the Paris Agreement and this is also the case when the analysis is run country-by-country rather than all countries combined. Moreover, important areas such as SDG 15 that is essential for the maintenance and enhancement of carbon sinks, have received less finance in recent years. Our results suggest that the publication of the NDCs and related transparency have not (yet) affected financing choices. Or, possibly, donor interests prevail. Additionally, the NDCs, as international documents, do possibly not fully reflect developing countries' priorities domestically. While we have not observed an improvement in finance coherence post-Paris, the effects of increased transparency through the NDC publication will probably be observed in later years. Future research should continue to follow this progress and go beyond the financing period assessed in this thesis (i.e. 2010-2018).

In the next stage of international negotiations for climate finance post-2025, reporting standards will be highly important to avoid over-reporting incentives of ODA climate relevance. If climate finance reporting standards improve in the future (Roberts et al., 2021), more accurate calculations of climate-relevant finance will allow for further insights. In particular, distinguishing between the effects of different financial instruments (e.g. grants vs loans) will be important. Moreover, better understanding additionality of all effects and the broad range of co-benefits and trade-offs will be essential to keep an overview of all relevant finance.

Ensuring horizontal coherence across the sources of finance for the Paris Agreement and the 2030 Agenda can help improve efficiency of resource-use. For this, better coordination among the relevant donors and a good understanding of climate-SDG interlinkages is essential. In doing so, contemplating specific country contexts could further increase effectiveness of financing through ownership and knowledge of the situation on the ground.

Recommendation:

- Bilateral and multilateral aid donors should seek to better tailor the distribution of climate-relevant finance across development areas to better match recipient countries' priorities (e.g. as reflected in the NDCs) and hence, to enhance country ownership, address most pressing needs, and support coherence of financial resources.

7.5.4 Coherence among international agendas and processes

The SDGs are highly comprehensive in their coverage of socio-economic and environmental areas, and the 2030 Agenda raises awareness on important interlinkages between them. However, the SDGs are only 'soft law' and, as such, they can only be successful if implemented through national and international 'hard law' and subsequently concrete measures (UNSG report). Implementing the SDGs can interfere with efforts to address climate change. Similarly, as shown in Chapters 4 and 5, implementing the Paris Agreement nationally has extensive effects on all SDGs and one of the key-affected SDGs is SDG 15 (life on land). According to Azizi et al. (Azizi et al., 2019) climate and biodiversity are the two strands of international environmental negotiations that make most reference to one another. For this reason, we looked in more detail at how these two areas are addressed internationally.

In Chapter 6, we analyse the gaps and opportunities to further integrate the climate and biodiversity international agendas. To that end, we explore how common drivers of climate change and biodiversity loss are addressed in key international decisions under the UNFCCC and the UN CBD and how the two processes refer to one another (investigating RQ5). Moreover, we analysed how the UN Environmental Assembly as an international agenda-setting body has addressed these issues in the past.

We found that the two agendas acknowledge their interlinkages and the common measures that address both biodiversity loss and climate change. In that sense, the climate and biodiversity agendas recognize that not only climate change but also climate action can have implications for biodiversity loss, and that the loss of ecosystems leads to GHG emissions and reduced carbon sinks. These interlinkages are recently also recognized in a IPCC-IPBES workshop outcome (Pörtner et al. 2021). Measures such as 'ecosystems-based adaptation' and 'nature-based solutions', address the objectives of both conventions and have recently entered the language of both. However, such measures are conceptually not yet well-defined. Moreover, the compulsory inclusion of land use, land-use change and forestry emissions reporting for developed countries also encourage activities that are relevant to both Conventions. Although such emissions reporting is not required for developing countries, these countries can apply for support for measures in this area.

Despite the mutual acknowledgement of impacts and some common measures, the two agendas are still insufficiently linked and important trade-offs remain unaddressed. First, the impacts of extended use of biomass energy on biodiversity are not appropriately addressed by the Conventions. Yet, all IPCC scenarios envision substantial biomass use and extensive afforestation to keep the global temperature below an 1.5°C increase without overshoot (IPCC, 2018a). Second, the land-use limitations posed by protected areas and the timescale mismatch of slow carbon absorption for natural ecosystem recovery relative to climate-mitigation needs are also not addressed. Third, while forests are extensively discussed as key carbon sinks (and sources), other important carbon sinks (and sources) such as wetlands or marine and coastal ecosystems, are mostly ignored. Similarly, we found that the UN Environmental Assembly refers to climate and biodiversity and the aforementioned gap only sporadically.

Moreover, concrete measures to address recognized impacts are absent in several key areas. Importantly, concrete measures in the agricultural sector to reduce GHG emissions, enhance carbon sinks, and protect biodiversity, are not provided. This topic has only recently more strongly picked up under the Paris Agreement. Moreover, while major direct and indirect drivers of climate change and biodiversity loss are recognized and addressed in UNFCCC and CBD decisions, urbanisation and trade are almost completely absent. The recent emphasis on sustainable consumption and production that we observed in the UN Environmental Assembly, opens the opportunity to further develop measures that indirectly address both climate change and biodiversity loss.

Our results further exemplify the interlinkages between climate action and the SDGs and how they play out in international negotiations. Here, we showed that the international agendas for climate and biodiversity, for example, remain limited in addressing their interlinkages. To support a coherent implementation of the SDGs, international agendas of all relevant areas should be integrated. The year 2021 offers a great opportunity to further integrate the international climate and biodiversity agendas due to an important line-up of events: the upcoming CBD COP in October that aims to reach agreement on the post-2020 Global Biodiversity Framework; the UNFCCC COP in November that will initiate the implementation of the Paris Agreement and that seeks agreement on international carbon markets under Article 6; the Food Systems Summit in September or October that will further offer opportunities to address food production as a common key driver of climate change and biodiversity loss.

Recommendation:

- The Secretariats of the UNFCCC and CBD and pertinent country negotiators should ensure a better integration of the climate and biodiversity international agendas to jointly address common drivers of climate change and biodiversity loss and to tackle potential trade-offs of action in one area on the other.

7.6 Concluding remarks: Boosting climate action ambition nationally and internationally

The main objective of my thesis was to explore how key enablers of ambitious climate action (Sections 7.1 to 7.4) have played out over time and across countries, and to develop policy-relevant tools that help to engage these enablers. To do so, I and my collaborators addressed five research questions (see intro) that addressed current gaps in the literature on the effects of these enablers. Additionally, we developed a set of policy-relevant tools and demonstrated their use in our analyses.

I and my collaborators answered the research questions and demonstrated the effects of selected enablers of ambitious climate action. First, we showed that international negotiations had an effect on the adoption of national climate strategies, legislation and targets (RQ1, Section 7.1). Second, we demonstrated that country contexts, as defined by key development indicators, have an effect on countries' conditional and unconditional GHG emissions reduction targets in the NDCs (RQ 2, Section 7.2). Third, we found that the focus of climate-relevant ODA is correlated with the SDG priority areas covered by NDC activities, but no further alignment is observed after Paris (RQ3, Section 7.4.3). Moreover, climate-relevant ODA still focuses more on climate-change mitigation, while recipients' NDC activities focus on adaptation (RQ 3, Section 7.3). Fourth, we provided a comprehensive overview of climate-change mitigation measures effects on the SDGs and suggested possible policy approaches to address these effects based on the relevant context dimensions (RQ 4, Section 7.4.2). We showed that G20 countries more often adopt climate-change mitigation measures with multiple positive effects on the SDGs, hence, showing the influence on climate action (Section 7.4.1). Finally, we found that UNFCCC and CBD make reference to one another and address common drivers, but major gaps and opportunities remain, for instance, with regard to agriculture and important non-forest ecosystems (RQ 5, Section 7.4.4).

Additionally, we developed a set of tools that address the enablers of ambitious climate action to support policy making and agenda setting. These tools offer the following policy-making support: allow countries to compare the ambition of their climate pledges in the context of key development indicators of capability and responsibility (Chapter 3); provide a complete SDG categorization of climate finance that supports a better assessment against recipients' SDG focus of pledges climate activities (Chapter 4); provide an overview of climate and SDG interactions in view of country context dimensions to support policy coherence improvements (Chapter 5); and a systematic overview of current gaps and opportunities for integration of the international climate and biodiversity agendas (Chapter 6). From a policy perspective, these tools and their results that are presented in my thesis, likely facilitate comparability, policy integration and improved matching of interests, and increase climate ambition among countries.

In this thesis, I showed how the five assessed enablers can influence climate action taken nationally and internationally. To boost climate action, international climate momentum needs to be maintained, countries need to be able to compare and to learn from one another to tackle barriers, climate finance must target ambitious countries, and policy coherence needs to be enhanced both nationally and internationally.

To adequately respond to the urgency to tackle dangerous anthropogenic climate change, countries need to leverage the opportunities offered by these presented enablers. To that end, countries need to consider the different levels of coherence in the implementation of climate action domestically. At the same time, international processes around climate change, biodiversity loss, sustainable development and other climate-relevant strands of international negotiations need to be better integrated to increase the chances of meeting their objectives. Measures such as increased comparability of country plans, improved transparency, reporting on interlinkages between SDGs actions and on consideration of trade-offs, and improved reporting standards, will be essential to ensure adequate progress towards internationally agreed goals and national objectives.

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Supplementary Material

Supplementary Material Chapter 2

Methods, data and additional figures

SM2.1: Categorization approach

Table SM2.1 Scoring approach applied to climate legislation and strategies

National climate legislation/strategies (from Dubash et al. 2013)[133]

(1) Climate legislation: An act that has been passed by a national parliament, that is in force, and that includes in its title or in its statement of objectives limits or reductions in greenhouse gas emissions. This legislation may include a national climate goal, but this is not a necessary condition. If a parliament does not exist, the equivalent government act necessary to pass legally enforceable measures should be used as the benchmark.

Not qualifying for this category:

- If there is no single overarching act, but multiple sectoral piecemeal acts in place, then a reasoned judgement must be made on whether these add up to a larger strategy. Normally, a single sectoral act only that includes as one of its objectives limiting GHGs would not be counted in the absence of evidence of a larger strategy.
- An adaptation-only focused act or one that focuses on accounting for emissions alone should not be counted.

(2) Climate strategy and coordinating body: One or more documents or statements passed by a national government to promote climate change mitigation, but not passed by a national parliament or through any other formal lawmaking process, which includes:

- Strategy, plan or framework for climate mitigation that states in its title and/or in its statement of objectives limiting or reduce GHG emissions. AND
- An active coordinating body charged with developing and implementing the strategy, plan or framework (meeting at least once in the last year).

133 Dubash, N. K., Hagemann, M., Höhne, N., & Upadhyaya, P. (2013). Developments in national climate change mitigation legislation and strategy. Climate Policy, 13(6), 649-664.

Not qualifying for this category:

- If there is no single overarching strategy, but multiple sectoral piecemeal strategies in place, then a reasoned judgement must be made on whether these add up to a larger strategy. Normally, a single sectoral strategy only that includes as one of its objectives limiting GHGs would not be counted in the absence of evidence of a larger strategy.
- An adaptation-only focused act or one that focuses on accounting for emissions alone should not be counted.

(3) None of the above: Includes countries that were studied but where no information suggesting climate legislation or strategy as defined above was found, even after a thorough search.

(4) Analysis incomplete: Includes countries that were studied, but where categorisation was not possible, because original or translated laws/strategies were not traceable, not public or in a language other than those available to the research team.

Table SM2.2 Scoring approach applied to GHG emissions targets

GHG emissions target
(1) GHG limitation target in national legislation: The target appears in an act that has been passed by a national parliament, and that is in force. If a parliament does not exist, the equivalent government act necessary to pass legally enforceable measures should be used as the benchmark.
■ The target can be defined either as percentage or total GHG emissions reductions compared to a base year or a baseline trajectory, or as GHG emissions intensity of GDP (gCO2/US$) compared to a base year or BAU trajectory.
■ The target must include at least CO2 emissions and at least energy-related emissions (may exclude GHG emissions from land-use, land-use change and forestry).
Not qualifying for this category: ■ Statements of government/ministers that are not included in an official document ■ International GHG reduction pledges, if they are not legally-binding (such as Kyoto, that was included) ■ If there is no overarching GHG emissions reduction target but only sectoral emissions targets ■ If target does not cover at least energy-related CO2 emissions ■ Feasibility reports and levels of GHG emissions defined as ‘trajectory’, ‘forecast’, ‘prediction’ or ‘expected’ values

(2) GHG limitation target: GHG limitation target passed by a national government, but not passed by a national parliament or through any other formal lawmaking process. This includes targets set in the Nationally Determined Contributions (NDCs) under the Paris Agreement, as these are defined and adopted by countries.

- The target can be defined either as percentage or total GHG emissions reductions compared to a base year or a baseline trajectory, or as GHG emissions intensity of GDP (gCO2/US$) compared to a base year or BAU trajectory.

- The target must include at least CO2 emissions and at least energy-related emissions (may exclude GHG emissions from land-use, land-use change and forestry).

Not qualifying for this category:

- International GHG reduction pledges, if they are not legally-binding (such as Kyoto, that was included)
- Statements of government/ministers that are not included in an official document
- International GHG reduction pledges, except for the NDCs targets
- If there is no overarching GHG emissions reduction target but only sectoral emissions targets
- If target does not cover at least energy-related CO2 emissions
- Feasibility reports and levels of GHG emissions defined as ‘trajectory’, ‘forecast’, ‘prediction’ or ‘expected’ values

(3) None of the above: Includes countries that were studied but where no information as defined above was found, even after a thorough search.

(4) Analysis incomplete: Includes countries that were studied, but where categorisation was not possible, because information was not fully traceable, not public or in a language other than those available to the research team. There are no countries under this category for GHG emissions targets as all countries have NDCs (except Nicaragua and Syria)) while data on these targets is generally more readily available

Table SM2.3 Scoring approach applied to renewable energy targets

Renewable energy target

(1) Renewable energy target in national legislation: The target appears in an act that has been passed by a national parliament, and that is in force. If a parliament does not exist, the equivalent government act necessary to pass legally enforceable measures should be used as the benchmark.

- The target can be defined either as production capacity, or as absolute increase or share of renewable energy increase compared to a base year, or as share of renewables or total capacity in the target year.

- The target must cover at least the electricity sector (although a clear distinction is made between targets that cover the total energy mix and those that cover only electricity).

Not qualifying for this category:

- Statements of government/ministers that are not included in an official document
- International renewables increase pledges
- If the target does not cover at least the electricity sector
- Feasibility reports and shares or installed capacity of renewables defined as 'trajectory', 'forecast', 'prediction' or 'expected' values

(2) Renewable energy target: Renewable energy target passed by a national government, but not passed by a national parliament or through any other formal lawmaking process. This includes targets set in the Nationally Determined Contributions (NDCs) under the Paris Agreement, as these are defined and adopted by countries.

- The target can be defined either as production capacity, or as absolute increase or share of renewable energy increase compared to a base year, or as share of renewables or total capacity in the target year.

- The target must cover at least the electricity sector (although a clear distinction is made between targets that cover the total energy mix and those that cover only electricity).

Not qualifying for this category:

- Statements of government/ministers that are not included in an official document
- International renewables increase pledges, except for those that are set in the NDCs
- If the target does not cover at least the electricity sector
- Feasibility reports and shares or installed capacity of renewables defined as 'trajectory', 'forecast', 'prediction' or 'expected' values

(3) None of the above: Includes countries that were studied but where no information as defined above was found, even after a thorough search.

(4) Analysis incomplete: Includes countries that were studied, but where categorisation was not possible, because information was not fully traceable, not public or in a language other than those available to the research team. We applied this categorisation to all countries that were not covered by the REN21 Global Status Report (2017)[134] nor the IEA database on Renewable Energy Policies and Measures[135] if no target was found for these countries through an additional search process on relevant websites and databases. This approach was taken as the REN21 and IEA databases have the highest coverage on this matter. However, if information in these databases could not be corroborated with additional sources, countries were scored '4' as some of the data in REN21 is based on interviews and may not reflected actual executive or legislative measures but only political statements.

Table SM2.4 Scoring approach applied to energy efficiency targets

Energy efficiency target
(1) Energy efficiency target in national legislation: The target appears in an act that has been passed by a national parliament, and that is in force. If a parliament does not exist, the equivalent government act necessary to pass legally enforceable measures should be used as the benchmark.
■ The target can be defined as percentage or total energy reductions or as energy intensity of GDP (J/US$) compared to a base year or BAU.
Not qualifying for this category: ■ Statements of government/ministers that are not included in an official document ■ International energy efficiency increase pledges ■ Multiple sectoral targets but no overarching target ■ Feasibility reports and energy efficiency levels defined as 'trajectory', 'forecast', 'prediction' or 'expected' values
(2) Energy efficiency target: Energy efficiency target passed by a national government, but not passed by a national parliament or through any other formal lawmaking process. This includes targets set in the Nationally Determined Contributions (NDCs) under the Paris Agreement, as these are defined and adopted by countries.
■ The target can be defined as percentage or total energy reductions or as energy intensity of GDP (J/US$)

134 REN21. (2017). Renewables 2017 Global Status Report. Paris, REN21 Secretariat, ISBN 978-3-9818107-6-9, Accessible at: http://www.ren21.net/wp-content/uploads/2017/06/17-8399_GSR_2017_Full_Report_0621_Opt.pdf.

135 International Energy Agency, Policies and Measures Databases, Global Renewable Energy, https://www.iea.org/policiesandmeasures/renewableenergy/ Last accessed: May 2017

Not qualifying for this category:

- Statements of government/ministers that are not included in an official document
- International energy efficiency increase pledges, except for those that are set in the NDCs
- Multiple sectoral targets but no overarching target
- Feasibility reports and energy efficiency levels defined as 'trajectory', 'forecast', 'prediction' or 'expected' values

(3) None of the above: Includes countries that were studied but where no information as defined above was found, even after a thorough search.

(4) Analysis incomplete: Includes countries that were studied, but where categorisation was not possible, because information was not fully traceable, not public or in a language other than those available to the research team. We applied this categorisation to all countries that were not covered by the IEA database on Energy Efficiency Policies and Measures[136] if no target was found for these countries through an additional search process on relevant websites and databases. This approach was taken as the IEA database are the most comprehensive and with highest coverage on this matter.

136 International Energy Agency, Policies and Measures Database, Energy Efficiency: https://www.iea.org/policiesandmeasures/energyefficiency/ Last accessed: May 2017.

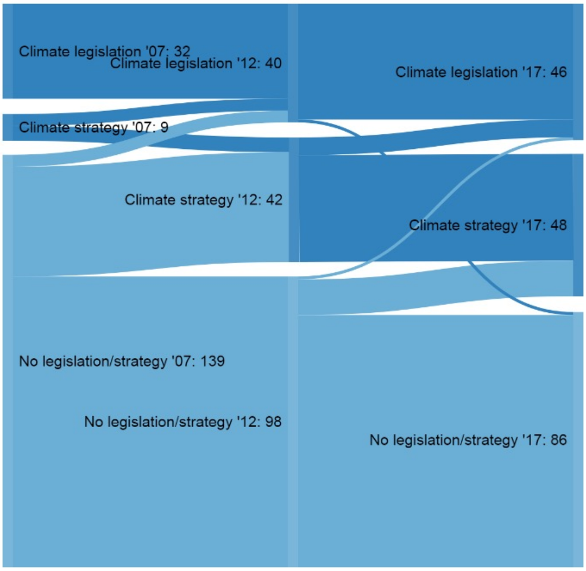
SM2.2: Main secondary data sources

Table SM2.5 Main secondary data sources used in this study

Name	Sectors covered	Countries	Website
Climate Policy Database	All	Worldwide	http://climatepolicydatabase.org/
IEA Addressing Climate Change	All	50 countries	http://www.iea.org/policiesand-measures/climatechange/
IEA Global Rene-wable Energy	Renewables	126 countries	http://www.iea.org/policiesand-measures/renewableenergy/
IEA Energy Effi-ciency	Energy-related	66 countries	http://www.iea.org/policiesand-measures/energyefficiency/
Climate Action Tracker	All	30 countries	http://climateactiontracker.org/countries.html
UNFCCC National Communications	All	Worldwide	http://unfccc.int/national_reports/items/1408.php
LSE & Columbia Global Climate Legislation	All	177 countries	http://www.lse.ac.uk/GranthamIn-stitute/legislation/the-global-clima-te-legislation-database/
(I)NDCs, UNFCCC	All	Worldwide	http://www4.unfccc.int/submissi-ons/indc/Submission%20Pages/submissions.aspx
ECOLEX	All	Worldwide	https://www.ecolex.org/
REN21 (2017)	Renewables	Worldwide	http://www.ren21.net/wp-con-tent/uploads/2017/06/17-8399_GSR_2017_Full_Report_0621_Opt.pdf
REEGLE	Energy-related	Worldwide	http://www.reegle.info/countries/
CAIT INDC	All	Worldwide	http://cait.wri.org/indc/

SM2.3: Additional figures

a)



b)

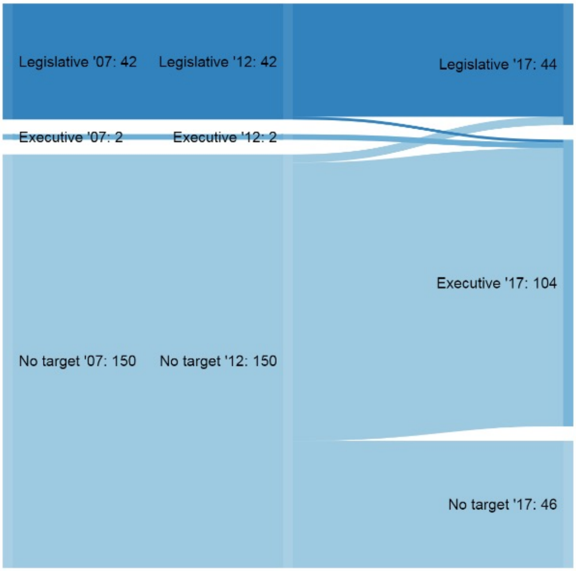


Figure SM2.1 a) Country category changes between climate legislation, climate strategy or no legislation/strategy from 2007 to 2012 and 2017. The numbers in the label represent the years and the number of countries in the given category. Only countries that could be analysed (not marked as 'Analysis incomplete') were included in this diagram, a total of 180 countries. b) Country category changes between legislative, executive or no GHG emissions target from 2007 to 2012 and 2017. The numbers in the label represent the years and the number of countries in the given category. All countries were included in this diagram, totalling of 194.

From the Sankey diagrams (Figures SM2.1 and SM2.2) we observe that changes in country categorization for climate legislation/strategies and GHG emissions targets occurs predominantly upwards and gradually (one step at a time between the three assessed years), with very few jumps from no strategy/target to legislation/legislative target or the other way around. On the other hand, energy efficiency and renewable energy targets (Figures 7 and 10 in the main paper) show extensive changes in categories, both upwards and downwards, including a substantial number of jumps from no target to legislative target, but fewer in the opposite direction. The stronger movement observed among these indicators may be due to the shorter time frames in which renewable energy and energy efficiency targets are set (often over periods of 5-10 years) compared to strategies and GHG emissions that tend to encompass long-term action. Furthermore, strategies and GHG targets have been pushed for a longer period in the international arena and this may have increased their domestic acceptability and adoption rates. By contrast, renewable energy and energy efficiency targets have only recently started to gain traction on the international stage, while at home they may be faced with stronger resistance due to the more direct impact on fossil fuel and energy intensive industries.

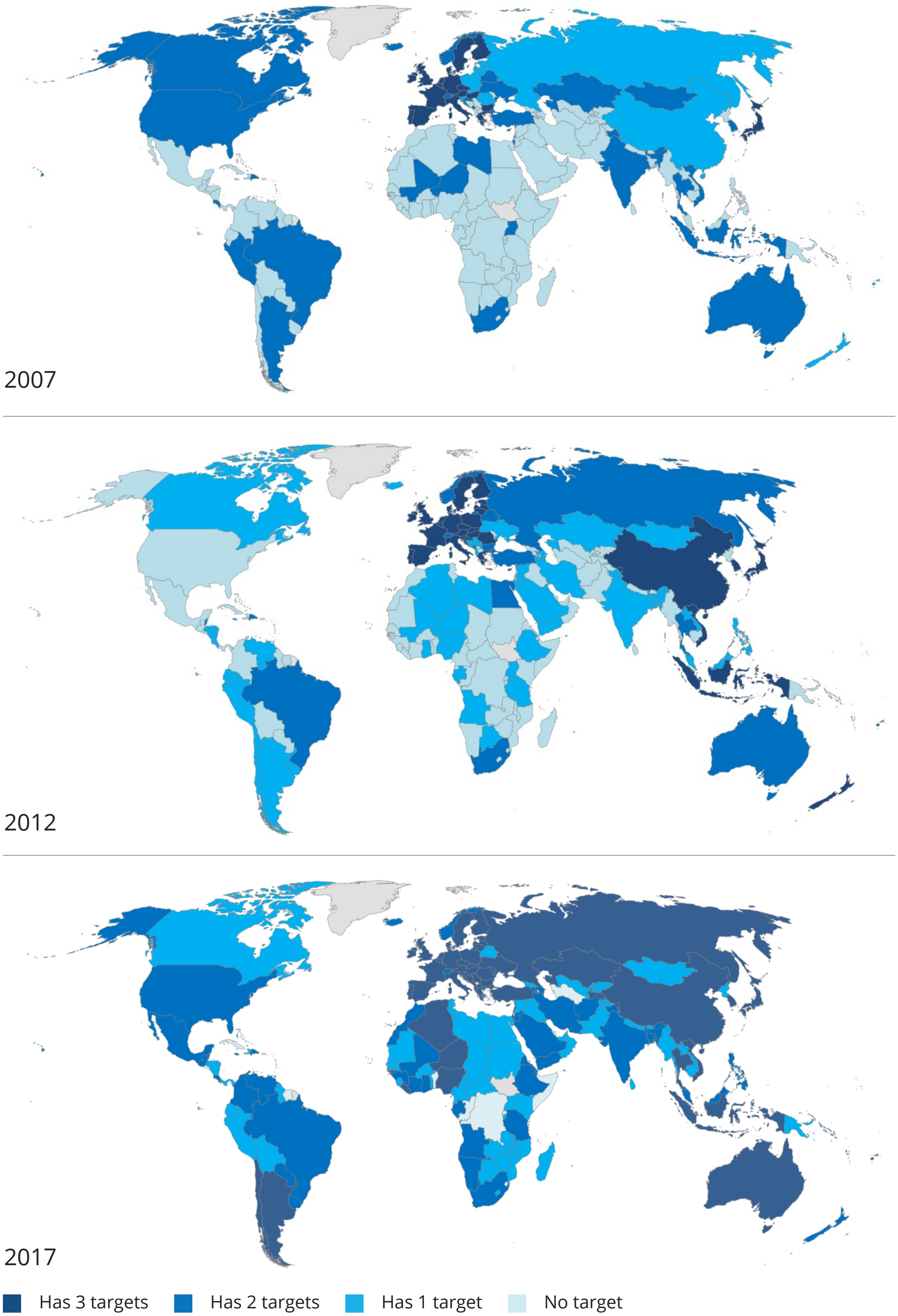


Figure SM2.2 Number of target types (GHG, renewables and energy efficiency) in 2007, 2012 and 2017

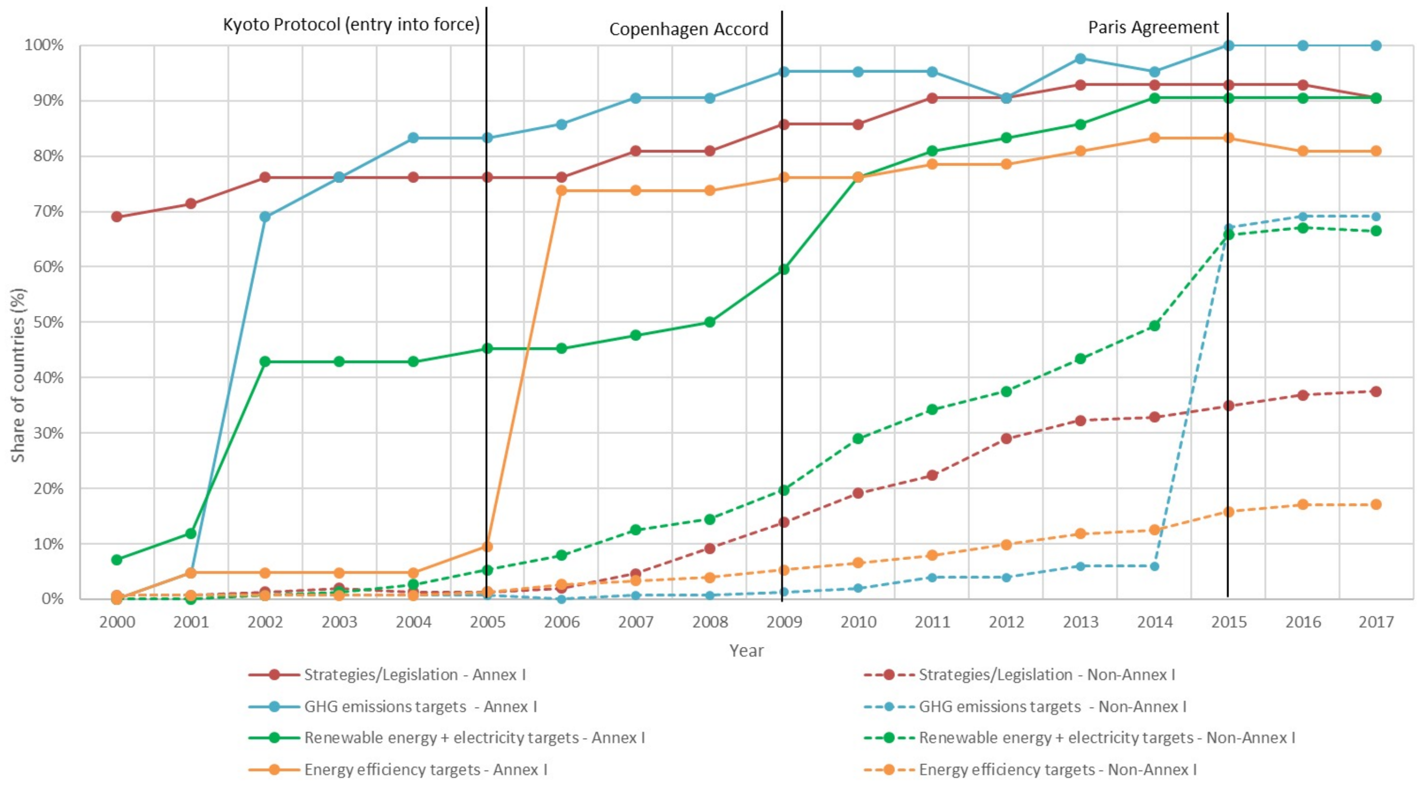


Figure SM2.3 Share of countries that adopted climate legislation, strategies or targets as percentage within the respective Annex group.

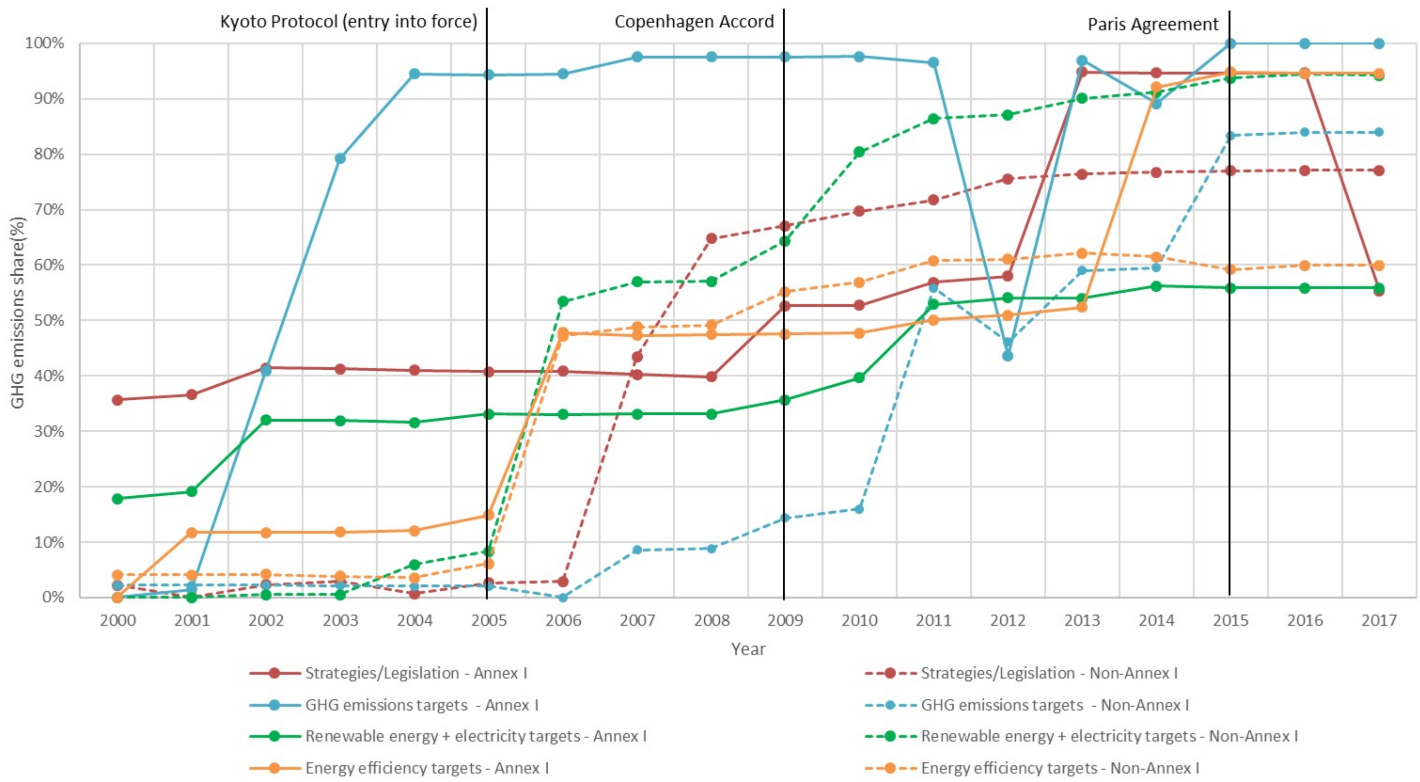


Figure SM2.4 Share of GHG emissions covered by climate legislation, strategies or targets as percentage of GHG emissions from respective Annex group.

Supplementary Material Chapter 3

Additional figures, including for updated NDCs' GHGe reduction targets

a)


GHG increase
GHG decrease
GDP/cap in 2014 (current $US/cap)
60,000
40,000
20,000
Monaco
Liechtenstein
Switzerland
Norway
Average historical GHG/cap
Singapore
Australia
Iceland
Canada
Andorra
Israel
New Zealand
Japan
European Union
Korea (South)
Saudi Arabia
Russian Federation
Average GDP/cap
Chile
Maldives
Kazakhstan
Brazil
Mexico
Belarus
Peru
Angola
Jamaica
South Africa
Ukraine
Paraguay
Zambia
Marshall Islands
Vietnam
Korea (North)
Central African
Historical GHG emissions (1850-2014) per 2014 population (MtCO2e/cap)
0
100
300
400
500
600
700
800
900
1,000

b)

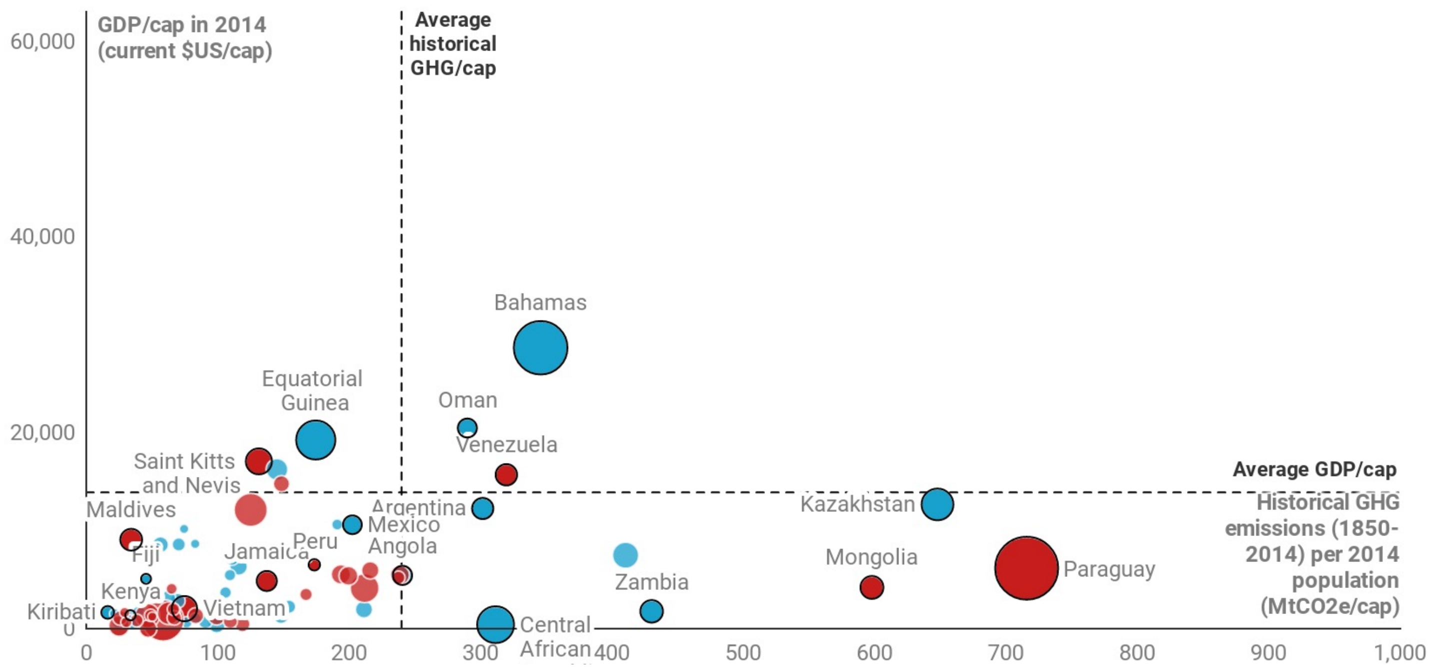
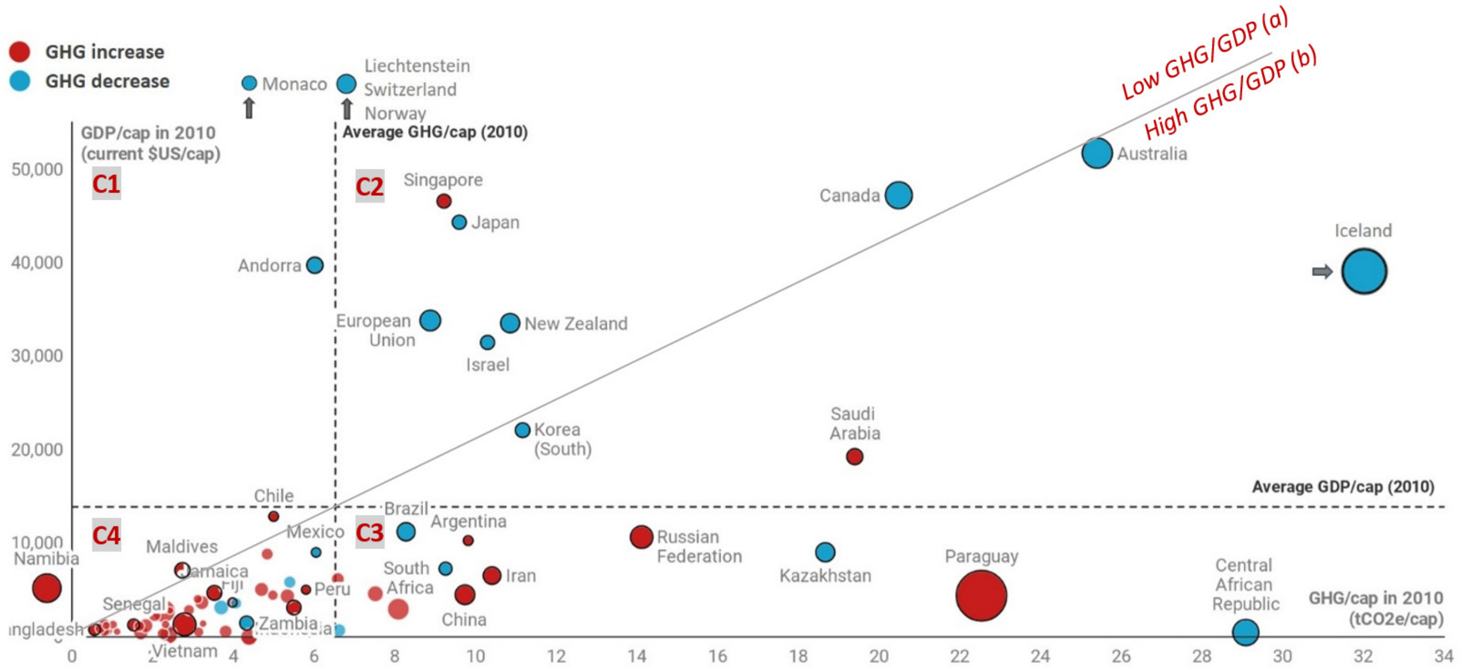


Figure SM3.1 Countries' positions relative to GDP/cap in 2014 and historical GHG/cap (1850-2014) and their respective a) unconditional and b) conditional (including unconditional share) first NDC GHG targets. The size of the bubbles shows the increase (red) or decrease (blue) in total GHG emissions, including LULUCF, by 2030 compared to 2010 in tCO2e/cap. Scale of bubble size is not equivalent in the two figures. Countries indicated with arrow were positioned outside the scale. The average GDP/cap and historical GHG/cap are averages across countries.

a)


GHG increase
GHG decrease
GDP/cap in 2010 (current $US/cap)
GHG/cap in 2010 (tCO2e/cap)
Average GHG/cap (2010)
Average GDP/cap (2010)
Low GHG/GDP (a)
High GHG/GDP (b)
C1
C2
C3
C4
50,000
40,000
30,000
20,000
10,000
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
Monaco
Liechtenstein
Switzerland
Norway
Singapore
Japan
Andorra
European Union
New Zealand
Israel
Canada
Australia
Iceland
Korea (South)
Saudi Arabia
Chile
Brazil
Argentina
Mexico
Russian Federation
Kazakhstan
Paraguay
Central African Republic
Maldives
Namibia
Jamaica
Fiji
Peru
South Africa
Iran
China
Senegal
Zambia
Vietnam

b)

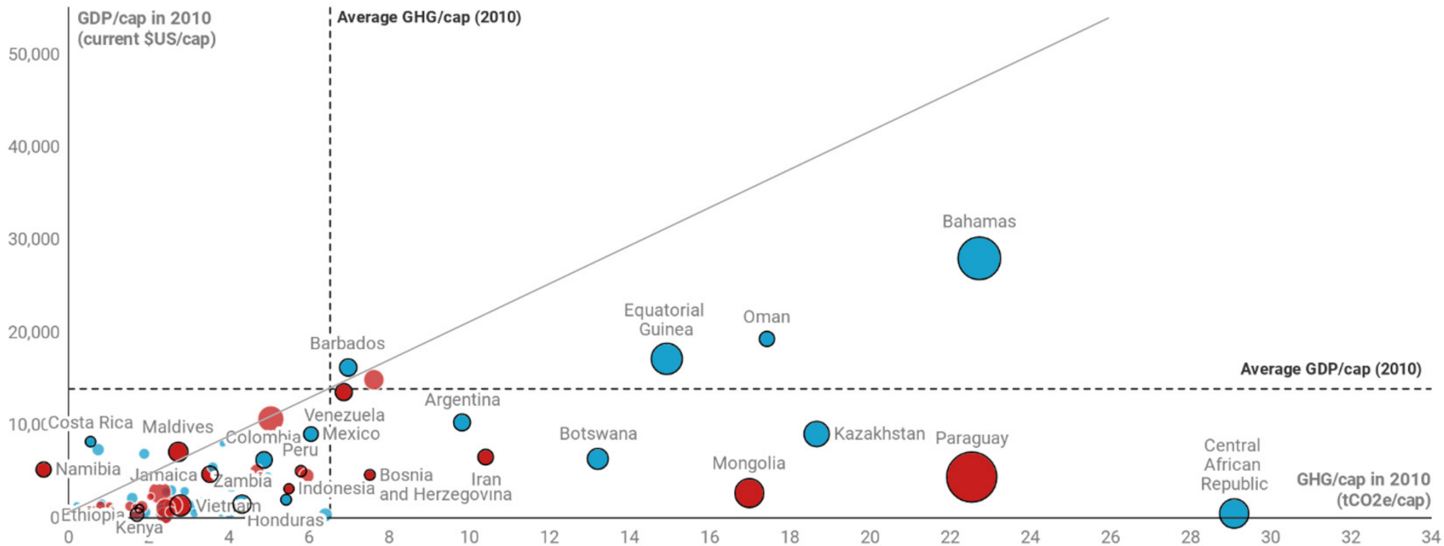
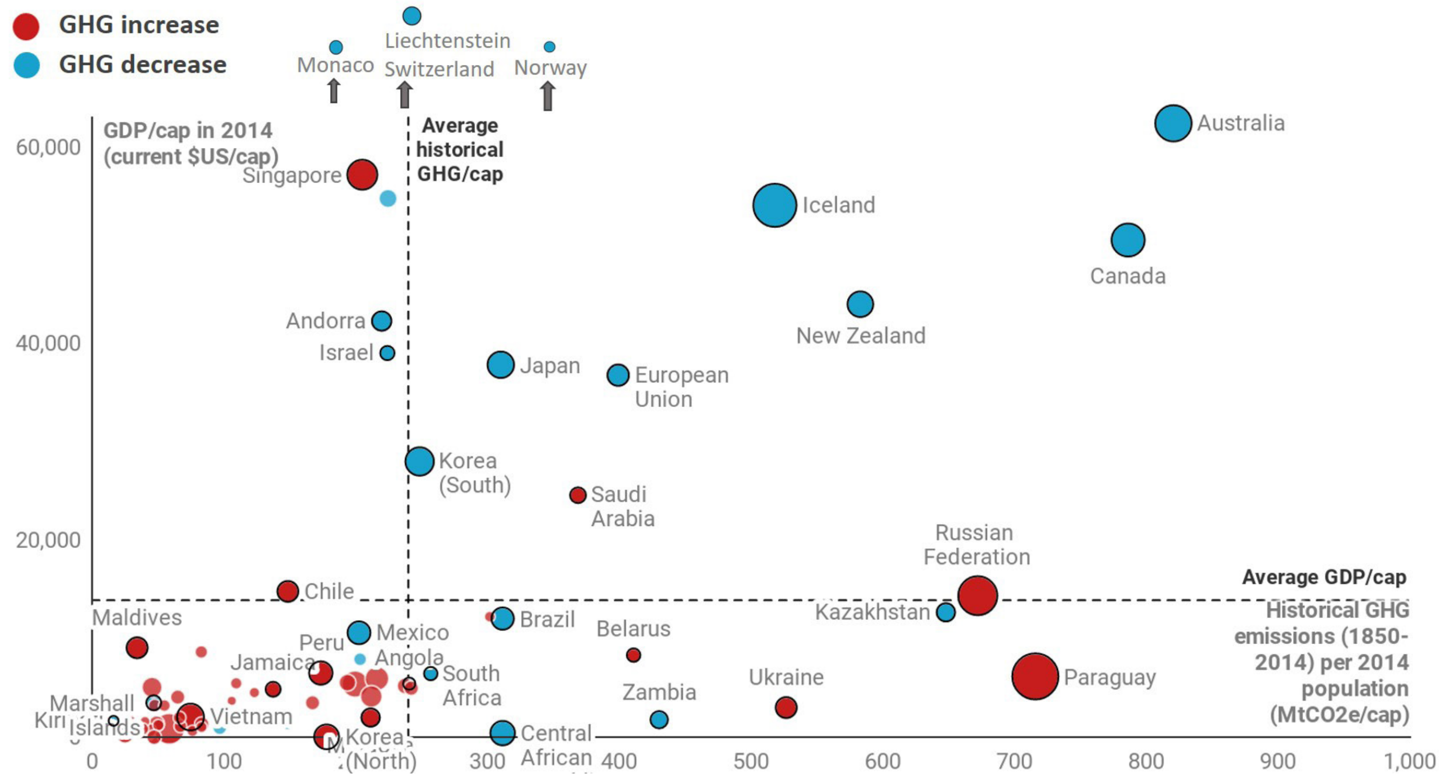


Figure SM3.2 Same as Figure 3.2 of the manuscript, but including updated NDCs. Countries' positions relative to GDP/cap and GHG/cap in 2010 and their respective a) unconditional and b) conditional (including unconditional share) first NDC GHG targets. The size of the bubbles shows the increase (red) or decrease (blue) in total GHG emissions, including LULUCF, by 2030 compared to 2010 in tCO2e/cap. Scale of bubble size is not equivalent in the two figures. Countries indicated with arrow were positioned outside the scale. The average GDP/cap and GHG/cap are defined as average across countries.

a)


GHG increase
GHG decrease
GDP/cap in 2014 (current $US/cap)
60,000
40,000
20,000
0
100
300
400
500
600
700
800
900
1,000
Average historical GHG/cap
Average GDP/cap
Historical GHG emissions (1850-2014) per 2014 population (MtCO2e/cap)
Monaco
Liechtenstein
Switzerland
Norway
Singapore
Australia
Iceland
Canada
Andorra
Israel
Japan
European Union
New Zealand
Korea (South)
Saudi Arabia
Russian Federation
Chile
Kazakhstan
Maldives
Brazil
Belarus
Peru
Mexico
Angola
Jamaica
South Africa
Ukraine
Paraguay
Zambia
Marshall Islands
Vietnam
Korea (North)
Central African

b)

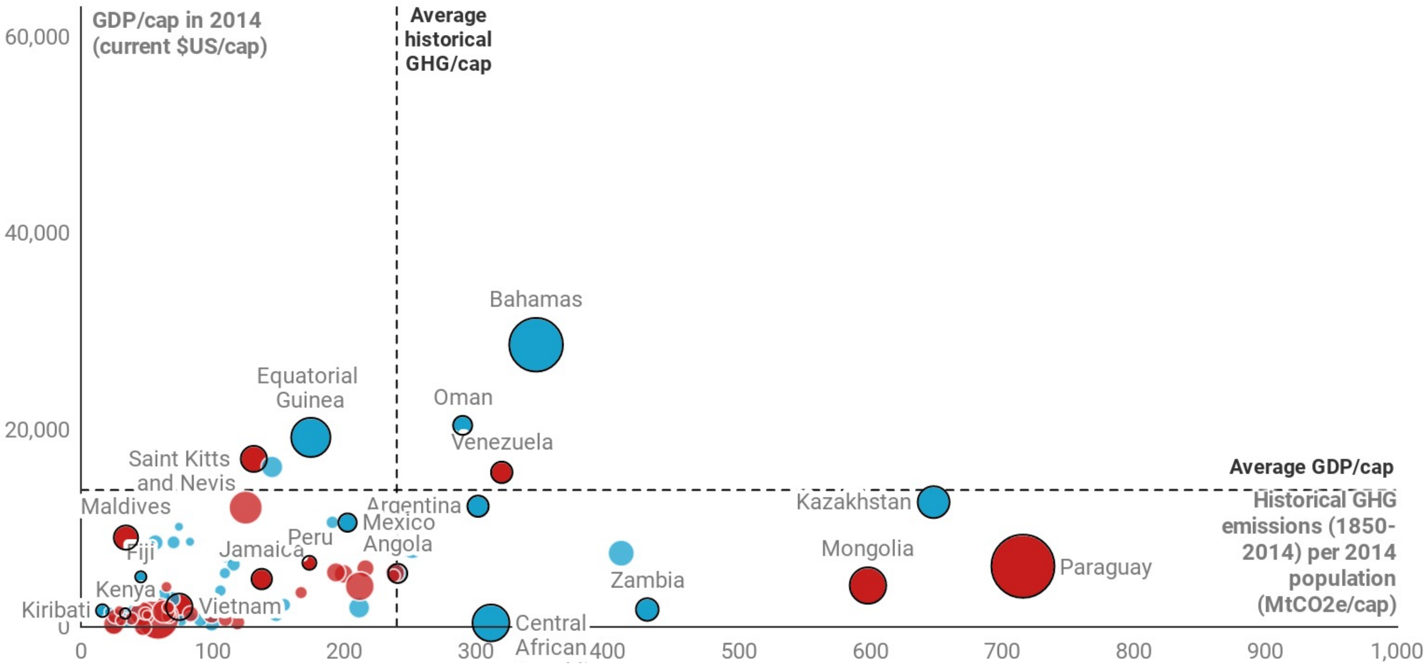
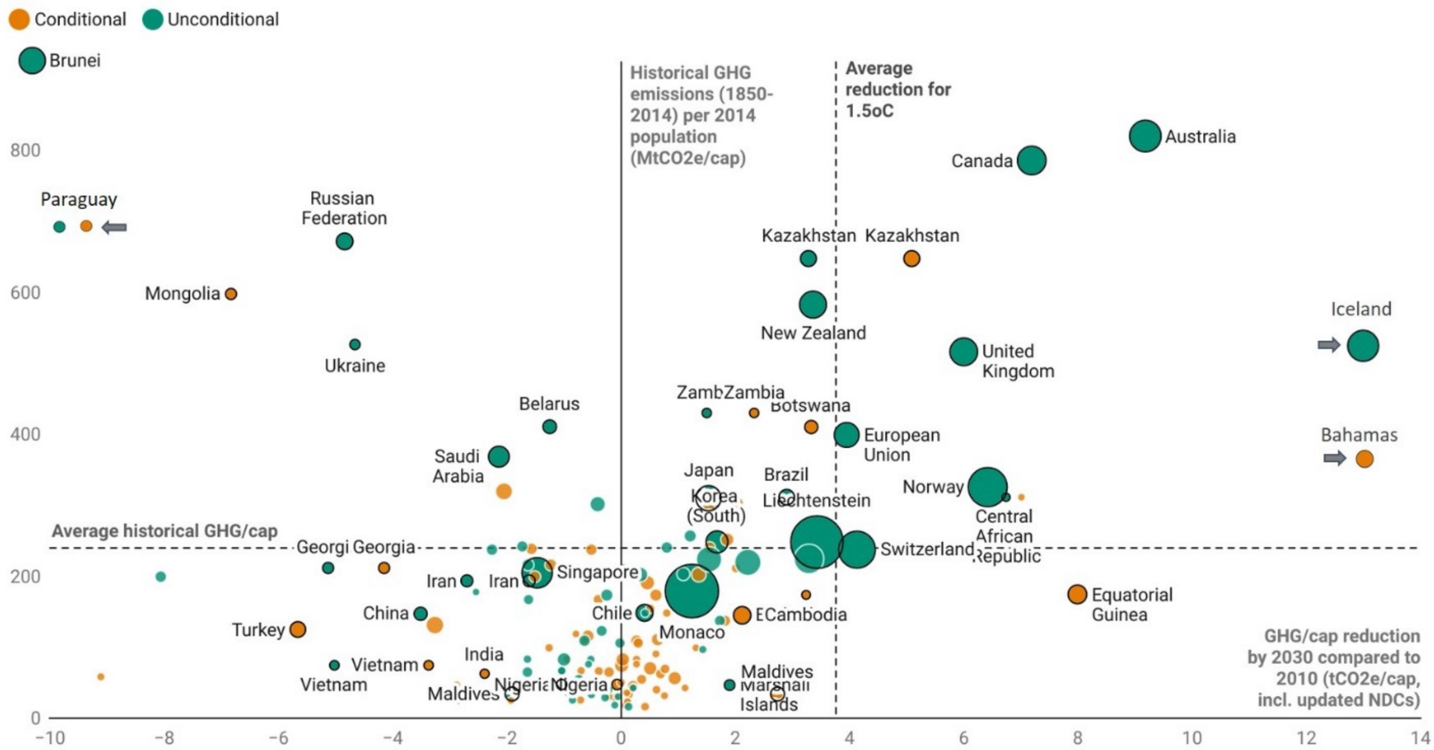


Figure SM3.3 Same as Figure SM3.2, but including updated NDCs. Countries' positions relative to GDP/cap in 2014 and historical GHG/cap (1850-2014) and their respective a) unconditional and b) conditional (including unconditional share) first NDC GHG targets. The size of the bubbles shows the increase (red) or decrease (blue) in total GHG emissions, including LULUCF, by 2030 compared to 2010 in tCO2e/cap. Scale of bubble size is not equivalent in the two figures. Countries indicated with arrow were positioned outside the scale. The average GDP/cap and historical GHG/cap are averages across countries.

a)



Conditional
Unconditional
Brunei
Historical GHG emissions (1850-2014) per 2014 population (MtCO2e/cap)
Average reduction for 1.5oC
Average historical GHG/cap
GHG/cap reduction by 2030 compared to 2010 (tCO2e/cap, incl. updated NDCs)
Paraguay
Russian Federation
Mongolia
Ukraine
Belarus
Saudi Arabia
Georgi Georgia
Iran
Iran
Singapore
China
Turkey
Vietnam
Vietnam
India
Maldives
Nigeria
Nigeria
Chile
Monaco
Japan
Korea (South)
Brazil
Liechtenstein
ZambZambia
Botswana
Kazakhstan
Kazakhstan
New Zealand
European Union
Switzerland
ECambodia
Maldives
Marshall Islands
Canada
Australia
United Kingdom
Norway
Central African Republic
Equatorial Guinea
Iceland
Bahamas
800
600
400
200
0
−10
−8
−6
−4
−2
0
2
4
6
8
10
12
14

b)

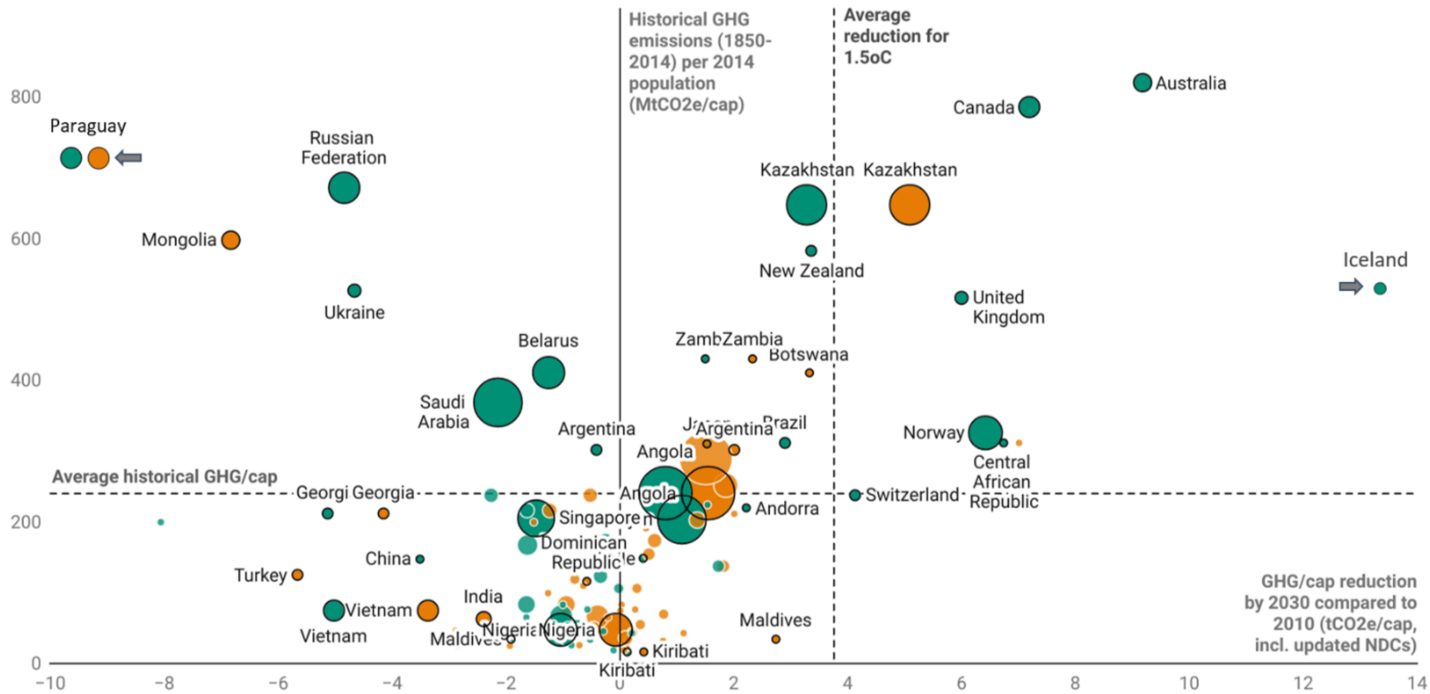


Figure SM3.4 Same as Figure 3.3 in the manuscripts, but including updated NDCs. Countries' first NDCs GHG/cap unconditional (green) and conditional (including unconditional share, orange) reduction targets relative to their historical GHG/cap emissions (1850-2014). Size of the bubbles is given by a) GDP/cap in 2014, and b) average share of fuel exports per GDP between 2010-2017. The vertical line labeled 'Average reduction for 1.5°C' indicates the global average reduction of GHG/cap needed by 2030 relative to 2010 to keep temperatures at a maximum increase of 1.5°C. Scale of bubble size is not equivalent across the two graphs. Countries indicated with arrow were positioned outside the scale.

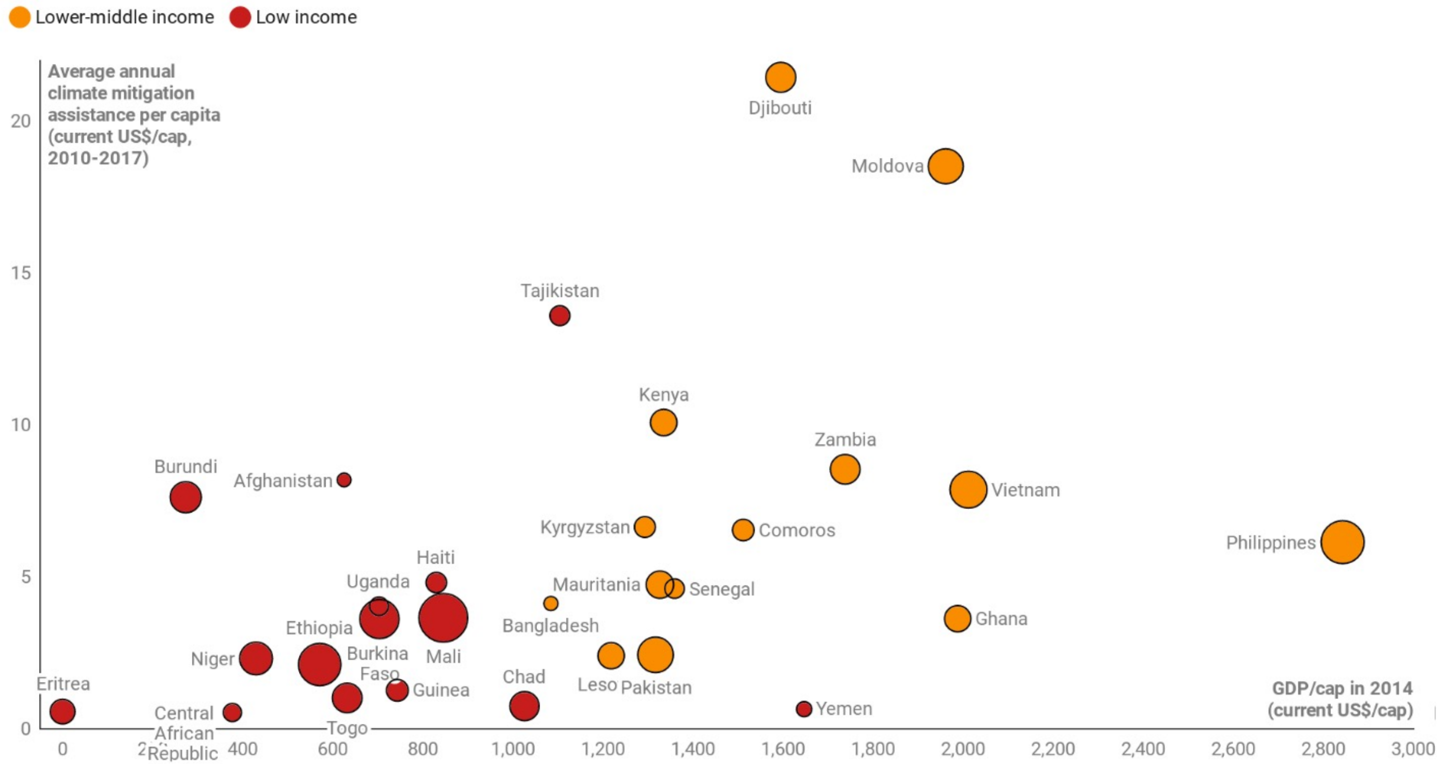


Figure SM3.5 Detail of Figure 3.6 of the main manuscript - finance received vs emissions reductions. International development assistance for climate change mitigation (reported under OECD) over the period 2010-2017 and respective GDP per capita of countries in 2010. The size of the bubbles indicates pledged GHG/cap reductions by 2030 compared to 2010 under conditional targets (tCO2e/cap). The colour of bubbles represents countries' economic groups in 2020 (World Bank categorization).

Supplementary Material Chapter 4

Additional figures

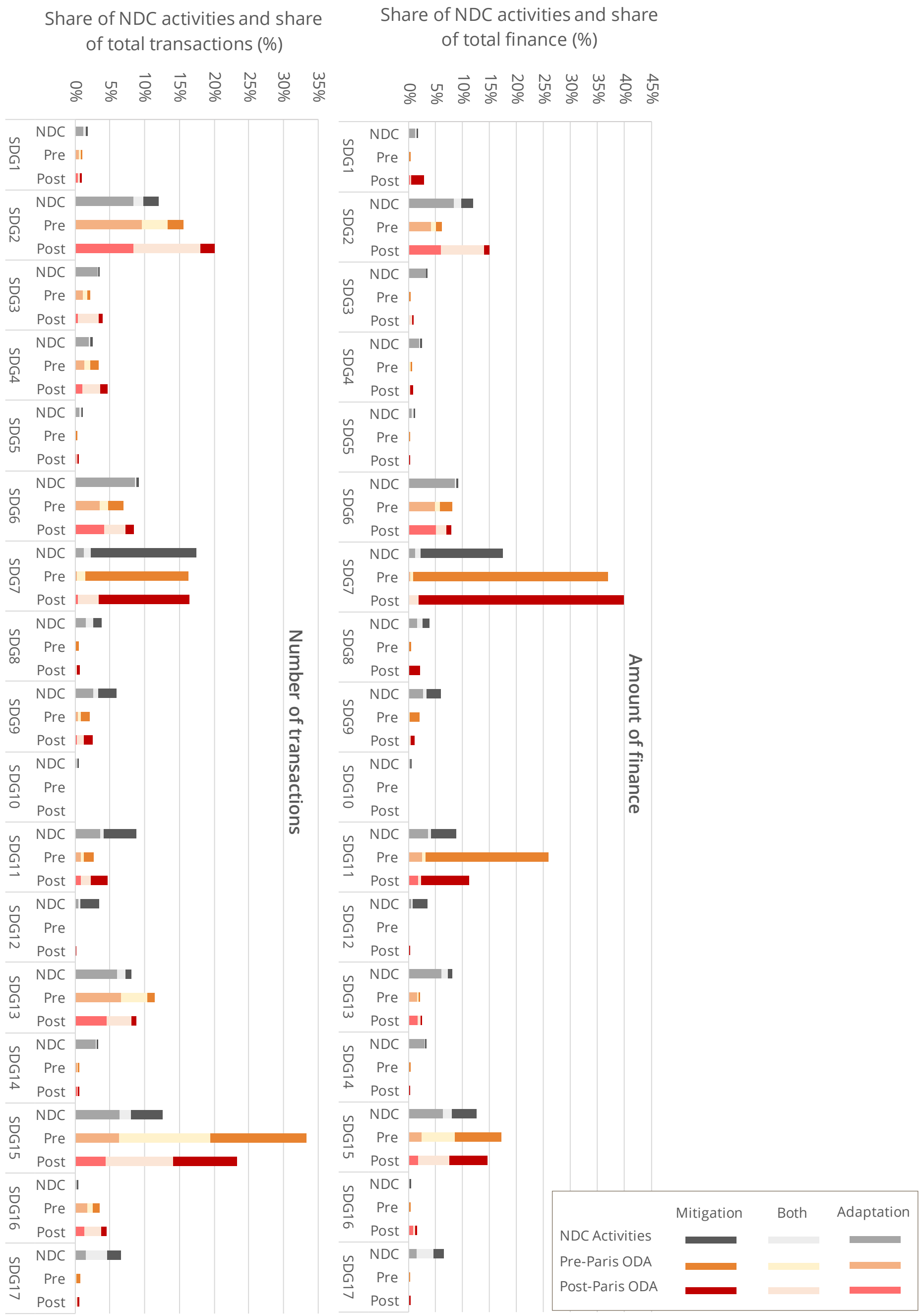


Figure SM4.1 Share of NDC climate activities, and pre- and post-Paris climate-relevant finance and respective transactions by SDG, divided based on their main target – climate change mitigation, adaptation or both. This figure presents financial data that marked climate change as 'principal' objective.

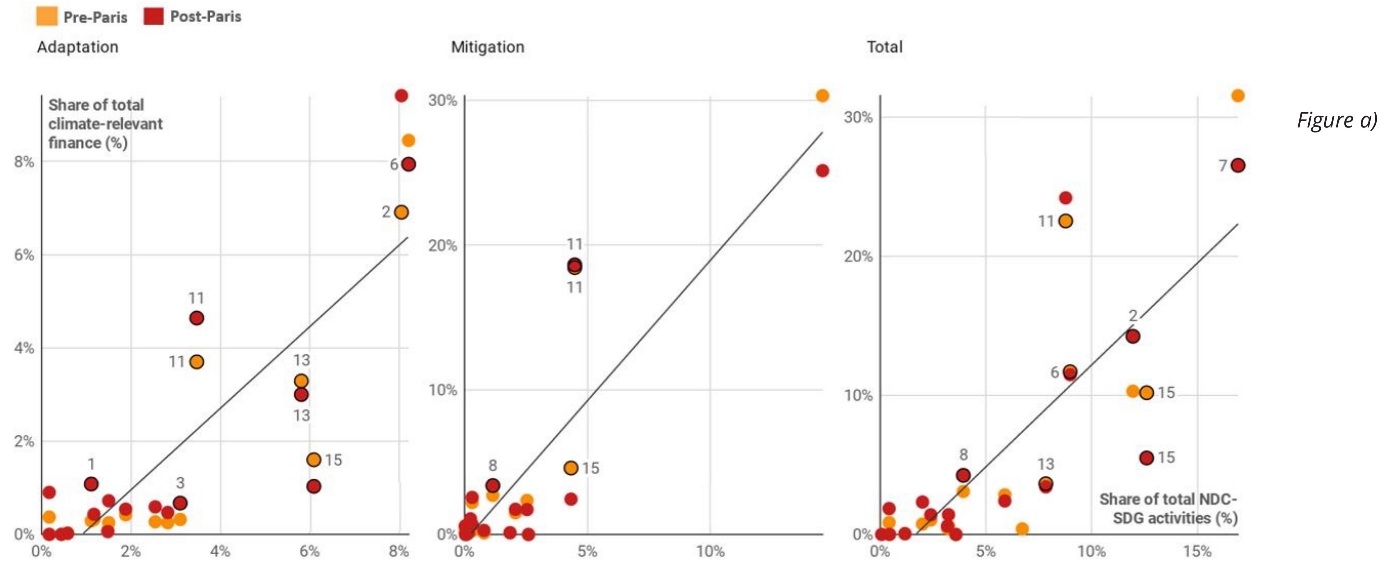


Figure SM4.2 Comparison between share of climate activities relevant to each SDG relative to all climate activities in the NDCs and the share of climate finance or transactions relevant to the respective SDG. The analysis is conducted across the main types of climate activities (adaptation, mitigation, total) and all SDGs, and covers all objective types of climate finance (principal, significant and climate component). Figure a) presents the analysis for climate-relevant finance, while Figure b) presents climate-relevant transactions. The in-figure numbers indicate the SDG number represented by the respective bubble.

Figure b)

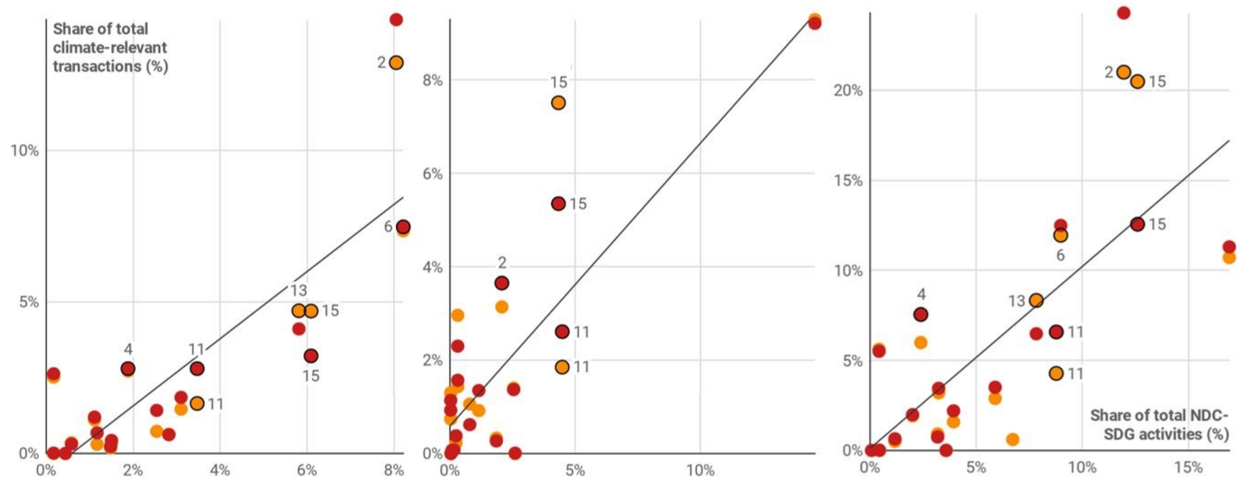


Figure SM4.2 (Continued) Comparison between share of climate activities relevant to each SDG relative to all climate activities in the NDCs and the share of climate finance or transactions relevant to the respective SDG. The analysis is conducted across the main types of climate activities (adaptation, mitigation, total) and all SDGs, and covers all objective types of climate finance (principal, significant and climate component). Figure a) presents the analysis for climate-relevant finance, while Figure b) presents climate-relevant transactions. The in-figure numbers indicate the SDG number represented by the respective bubble.

Supplementary Material Chapter 5

Positive and negative effects of climate-change mitigation measures on the SDGs

The sections below present impacts of climate change mitigation measures on specific SDG targets, as identified through literature review. This material includes only direct (first order) impacts and covers relevant SDGs. The language used here suggests whether the impacts are context dependent or independent, through wording such as "could/can/might/may" and "would/do(es)", respectively. For a visual representation of these impacts and their categorisation based on the scoring method developed in this paper, we recommend consulting the supplementary material in Excel format.

SDG1 – No poverty

Energy is an essential enabling element to a large number of human activities. For this reason, energy unaffordability was defined here as one dimension of poverty (SDG 1.2). Increase in energy prices due to energy (CO2) taxes would lead to a rise in energy poverty among economically vulnerable people if complementary attenuating measures, such as subsidies or exemptions for poor households, are not implemented (Cameron et al., 2016; Hirth & Ueckerdt, 2013). Furthermore, energy price increase can also be the result of use of more expensive energy technologies or of a higher demand for electricity, for instance, through electrification of the transport systems. However, an electrification of the transport sector may protect the poor from volatile oil prices. While nuclear energy and renewables are competitive with some types of fossil fuels (especially gas) in a few countries, this is not the case everywhere and measures such as feed-in tariffs are still necessary to keep the prices low for the public while making renewables competitive with fossil fuel energy sources. Moreover, waste-to-energy tends to be more expensive than other sources of electricity and heat in most situations (U.S. Department of Energy, 2019). Nevertheless, some renewables have reached price parity and are at times even cheaper than fossil fuels in some countries (Borenstein, 2012; Evans et al., 2009; Hirth & Ueckerdt, 2013; NEA, 2018; Ouyang & Lin, 2014). Moreover, (bioenergy) carbon capture and storage ((BE)CCS) used with power plants would always lead to higher energy costs as the carbon capture and storage system itself requires energy to operate, hence, increasing the energy consumption of the plant (Rubin et al., 2015). Nevertheless, for BECCS this additional required energy could be considered productive as it leads to a carbon sink (negative emissions) rather than just GHG emissions avoidance. On the demand side, upfront costs of energy efficiency improvements would most likely be over-compensated by lower energy needs in the long-run and would lead to lower energy prices. This would decrease energy poverty. For instance, observed rebound-effects (i.e. increased consumption) after improvements in energy efficiency could be an indication that there was a higher need for energy previous to the price decrease and that it was not affordable (assuming that the effect is not a result of energy waste alone) (Cayla & Osso, 2013; Greening et al., 2000; Herring & Roy, 2007; Sorrell, 2007; Ürge-Vorsatz & Tirado Herrero, 2012; Winkler et al., 2002).

While energy unaffordability is an indicator of poverty, the lack of access to energy deprives people of this basic service altogether (SDG 1.4). In that regard, off-grid renewable sources can facilitate coverage of electricity in remote areas (Casillas & Kammen, 2010; Pueyo et al., 2013; REN21, 2016). However, forest and ecosystems conservation and rehabilitation to increase the carbon sink potential can limit access of communities in the area to biomass for energy, as well as land and natural resources (SDG 1.4) that might be essential for their livelihoods (Charnley, 2005). If a reasonable use of resources for energy is allowed, the communities can benefit from the conservation of respective ecosystems. This is also the case for large photovoltaic (PV), concentrated solar power (CSP), hydropower and biofuel production projects that require large areas of land and, in some cases (most common for hydropower), could additionally lead to communities displacement and related impoverishment (Dombrowsky et al., 2014; Moore et al., 2010). However, occurrence of these negative impacts depends on existence of communities in affected area.

SDG2 – Zero hunger

Policies supporting biofuel production can lead to competition between climate-change mitigation and food security targets (SDG 2.1) by reducing the surface area or increasing the price of land available for agriculture (Finco & Doppler, 2010; Hasegawa et al., 2015, 2018; Lotze-Campen et al., 2014; Lundberg et al., 2015; Rogelj et al., 2018; Smith et al., 2013; Van der Horst & Vermeylen, 2011). Similarly, forest and nature protection can also reduce available land for food production and limit access of vulnerable communities to land and natural resources (SDGs 2.1 and 2.3) (Charnley, 2005; Smith et al., 2010), but communities may benefit if access is allowed. Furthermore, taxes on CO2 emissions from agriculture would increase food prices (absent subsidies) and limit food affordability.

On the positive side, climate policies that support the use of biofuels and low-emissions agriculture facilitate the introduction of new technologies, infrastructure and knowledge for efficient and sustainable food production (SDG 2.3) (Smith et al., 2014). Examples of such methods and technologies include no-tillage agriculture, which reduces GHG emissions, water evaporation and loss of soil nutrients; optimized water and fertilizer delivery, which reduces GHG emissions, run-off, land-use extent for the same quantity of food, soil erosion and desertification; and direct seeding of rice, which substantially reduces GHG emissions caused by crop water immersion, and water and energy use, and improves soil quality through less soil compaction (World Economic Forum, 2011). These agricultural practices substantially reduce production costs and required labour, leading to an increased income for farmers (SDG 2.3) and productivity per labour input (SDGs T2.3 and T2.4) for both small- and large-scale farmers (World Economic Forum, 2011). Mixing agricultural and livestock practices can also increase productivity while reducing emissions and demand for land (Bogdanski, 2012; Thornton, 2010). On the downside, this increase in efficiency could reduce agricultural jobs (SDG T2.3). However, emerging bioenergy use can open access to untapped markets and, if adequately implemented, increase small-holder farmers income and jobs (Berndes et al., 2016; Brüntrup et al., 2016; Gohin, 2008) (SDG T2.3).

Agricultural practices for climate-change mitigation make food production systems more sustainable, can help improve ecosystems and soil quality (SDG T2.4) and could consequently increase resilience to changes in climate (Smith et al., 2014; World Economic Forum, 2011). Nonetheless, poorly managed bioenergy monocultures can have the opposite effect by decreasing soil quality, water availability and biodiversity, and hence, weakening ecosystem resilience (Bonsch et al., 2016; Davis et al., 2013; Dias de Oliveira et al., 2005; Finco & Doppler, 2010; von Blottnitz & Curran, 2007). Finally, from a behavioural perspective, decreased food waste and lower consumption of livestock combined with cultivation of food crops instead of feed can increase food availability (Lamb et al., 2016; Tilman & Clark, 2014). The use of more efficient cookstoves that last longer can also enhance food security (Berrueta et al., 2017).

SDG3 – Good health and well-being

A broad spectrum of air pollutants is produced through combustion of fossil fuels and other activities that jointly lead to GHG and other polluting emissions. Hence, tackling GHG emissions directly lowers air pollution (especially NOx and SOx but also volatile organic compounds, carbon monoxide, black carbon, particulate matter and organic carbon) (Braspenning Radu et al., 2016). Furthermore, climate-change mitigation measures reduce water and soil pollution from leakage during fossil-fuel extraction, transport, production and use, and from livestock and intensive use of nutrients (Atilgan & Azapagic, 2015; McMichael et al., 2007) (SDGs 3.4, as sources of non-communicable diseases, and SDG 3.9). Examples of GHG emissions measures with positive impacts on air, water and soil pollution are energy-efficiency improvements, use of renewable sources, cleaner transportation, reduction in material and energy demand, reduction in agricultural burning practices and improved cooking stoves, when the assumed business as usual implies the use of fossil fuels (Anenberg et al., 2012, 2013; Creutzig et al., 2012; Haines et al., 2007; Haines & Dora, 2012; International Energy Agency, 2016; von Blottnitz & Curran, 2007; West et al., 2013; Woodcock et al., 2009). A reduced demand for meat would lower the risk of zoonotic pathogens (SDG 3.3) (Klous et al., 2016). Moreover, in countries where meat consumption is high, a lower demand would offer numerous health benefits. Nevertheless, this measure could be problematic in developing countries where the population may not be able to obtain the needed daily nutrients from vegetal sources (Garnett, 2011).

However, measures with potentially negative impacts on air, soil, and water are bio-energy, (BE)CCS, nuclear, gas and geothermal energy sources. The use of bioenergy leads to air pollution, but the net impact on air quality depends on the fuel quality and on the fossil fuel source replaced. Furthermore, bioenergy production might increase the use of fertilizers and consequent emissions to soil and water (Dias de Oliveira et al., 2005). While (BE)CCS reduces SOx and particulate matter, the techno-logy requires additional energy to be operated and this leads to an increase in NOx and NH3 (European Environment Agency, 2011). Furthermore, (BE)CCS and nuclear energy pose a risk of CO2 and radioactive material leakage, respectively, to air, soil, and water, with potentially catastrophic consequences in the case of nuclear energy (IPCC, 2014). However, outside these very rare events, coal leads to even higher radiation exposure per unit of electricity produced for both the public and workers as compared to nuclear energy (UNSCEAR, 2016; IPCC, 2014; Markandya and Wilkinson, 2007).

The use of renewable energy resources and electric transportation might raise concerns on the increase in pollutants such as cadmium for solar PVs and lithium for batteries, and requires appropriate toxic material management. However, fossil fuel extraction, processing and use lead to substantial emissions of a wide variety of toxic compounds, for instance, mercury and lead (Atilgan & Azapagic, 2015; Duan & Tan, 2013; Pirrone et al., 2010). Some methods of gas extraction, such as fracking, lead to soil and water pollution by injection of water and chemicals into the ground. However, other gas extraction methods might have lower impacts than coal mining and avoid transport-related oil spills (Atilgan & Azapagic, 2015; IPCC, 2014; Jaramillo et al., 2007; Markandya & Wilkinson, 2007). Geothermal energy can lead to emissions of hydrogen sulphide (H_2S) and ammonia (NH_3) to air and to discharge of thermal and polluted water with dissolved chemicals such as sodium chloride (NaCl), boron (B), arsenic (As) and mercury (Hg). CO_2 and CH_4 are also emitted to air (Kristmannsdóttir & Ármannsson, 2003).

Road traffic accidents can be reduced through transport-related climate-change mitigation measures, such as improved urban planning and infrastructure investments to reduce traffic congestion, and modal share switch to increased use of public transport (Creutzig et al., 2012; Haines & Dora, 2012; Pridmore et al., 2017) (SDG 3.6). However, an increased use of silent electric vehicles can negatively affect road safety, if warning sounds are not implemented (IPCC, 2014), while the increased use of bicycles poses an additional accident risk when it is not paired with adequate infrastructure (SDG 3.6). Finally, lower levels of noise and modal switches to active travel modes are likely to have a positive influence on mental and physical health of citizens (Saunders et al., 2013; Woodcock et al., 2009). On the contrary, placement of wind turbines close to households can affect residents through noise and intermittent shadows (Evans et al., 2009). A reduction in meat consumption in areas where consumption is high can also have positive effects on health, reducing risks of non-communicable diseases (Bustamante et al., 2014) (SDG3.4). In energy deprived households, improvements in energy efficiency may increase warmth and reduce humidity, helping to reduce a series of health risks, such as cardiovascular and respiratory illnesses (Huebner et al., 2013; Zhao et al., 2017).

4 QUALITY EDUCATION

SDG4 – Quality education

Information and education measures for GHG emissions reduction include environmental product labels, information campaigns and specialized training. These promote sustainable development and sustainable lifestyles, raising public awareness of environmental issues (SDG 4.7). Moreover, education and vocational training directly contribute to the increase in number of people with vocational skills (SDG 4.3, 4.4 and 4.5).

SDG5 – Gender equality

Measures that support energy efficiency in buildings and more effective cookstoves would particularly benefit women, who tend to spend a disproportionate amount of time at home in most communities (Berrueta et al., 2017). Moreover, as women tend to play an important role in agricultural activities, special attention needs to be given to ensure that regulations in this sector do not overburden women. In particular, agricultural taxes may affect women farmer's income and food availability, but increased productivity could have a positive effect (Jost et al., 2016; Terry, 2009). Similarly, women's reliance on local ecosystem resources for food and wood puts them in a vulnerable situation when conservation measures restrict access, but they can benefit from inclusive ecosystem conservation measures (Katila et al., 2017; Larson et al., 2015).

SDG6 – Clean water and sanitation

Water-use efficiency can be improved through climate-change mitigation policies, such as the elimination of water intensive power plants (e.g. coal-fired power plants), improvements in energy production and use efficiency, and water efficient agriculture, such as precision agriculture and direct seeding of rice (see examples in SDG2), helping to avoid water-use conflicts (Byers et al., 2014; Chuang et al., 2009; Fricko et al., 2016; Fujimori et al., 2017; Kyle et al., 2013; Reidinger, 1974; Rio Carrillo & Frei, 2009; Spang et al., 2014; World Economic Forum, 2011) (SDGs 6.1 and 6.4). However, measures supporting bioenergy (Bonsch et al., 2016; Fingerman et al., 2011; Mouratiadou et al., 2016; Wu et al., 2009), concentrated solar power (CSP), nuclear (Byers et al., 2014; Chuang et al., 2009; Spang et al., 2014), geothermal (Rybach, 2003; Shortall et al., 2015) and hydro-energy (T. Abbasi & Abbasi, 2011; Kelly-Richards et al., 2017; Premalatha et al., 2014; Zhang et al., 2015) could increase or decrease water use and the access of communities to these resources, depending on the water consumption of the fossil fuel energy options replaced.

Moreover, the above-mentioned measures would positively or negatively affect thermal (except hydropower) and non-thermal water pollution, depending on the energy source they replace (Spang et al., 2014) (SDG 6.3). In that regard, energy efficiency and switching to alternative technologies for cooling (e.g. air-cooling) and electricity production (solar PV and wind) would reduce thermal and non-thermal water pollution (Byers et al., 2014; Fricko et al., 2016; Raptis et al., 2016) (SDG 6.3). Nonetheless, the increase in energy demand at power plants with CCS installed would lead to an increase in energy-related water use and thermal pollution (SDGs 6.1, 6.3 and 6.4). In industrial settings, carbon capture and utilisation (CCU) could be optimized to reduce water demand (Brandl et al., 2017). On the demand side, electric transportation could lead to an increase in water use and thermal pollution if provided electricity comes from water-intensive sources (King & Webber, 2007) (SDGs 6.1, 6.3 and 6.4). Non-thermal water pollution impacts are discussed under SDG3.

Altogether, aforementioned positive impacts as well as protection and restoration of forest areas, peat lands and other ecosystems for climate-mitigation purposes, help preserve fresh water bodies and avoid water quality issues, such as eutrophication (Eory et al., 2017; Smith et al., 2013) (SDG 6.6). Similarly, in the case of reforestation, original water ecosystems could be restored (Dooley & Kartha, 2018)). Nevertheless, water use for forest plantations can lead to water stress (Kibria, 2015; Lamb et al., 2016). Therefore, in-depth environmental impact assessments need to be undertaken for bioenergy, CSP and nuclear (SDG 6.6) and with particular attention in the case of hydro-energy, tidal and wave energy (SDG 6.6) to ensure water ecosystem impacts are not increased as compared to the replaced fossil fuel energy option (see also SDG15). For instance, in the case of hydro-energy natural areas are inundated to make space for the water reservoirs and the original route of the river might be diverted, leaving some communities without water resources. Furthermore, dams lead to sediment deposition and interfere with freshwater wildlife (T. Abbasi & Abbasi, 2011; Kelly-Richards et al., 2017; Premalatha et al., 2014; Zhang et al., 2015). Similarly, tidal energy may lead to sediment redistribution and affect marine life. However, if appropriately implemented, negative impacts can be minimized and certain benefits can be achieved in support of ocean biodiversity (Gill, 2005; Inger et al., 2009; Neill et al., 2012). In contrast, fossil fuel burning releases nitrogen oxides and sulfur oxides which make water bodies acidic. This is also an issue in the case of biomass and biofuel burning.

7 AFFORDABLE AND CLEAN ENERGY

SDG7 – Affordable and clean energy

Climate-change mitigation and SDG7 are strongly interlinked. Firstly, tackling GHG emissions implies increasing the share of low- and zero-carbon energy technologies, such as renewables (SDG 7.2). A second approach to address climate change is to substantially increase energy efficiency and lower energy demand in all sectors (SDG 7.3). Furthermore, both energy-efficiency improvements and renewable energy share increase could lead to more reliable energy systems (energy security) by reducing dependence on limited natural resources, with especially positive effects in countries with high energy imports (Bollen et al., 2010; Cherp et al., 2013; IEA, 2005; McCollum et al., 2013, 2014) (SDG 7.1). However, high reliance on intermittent energy sources and an increased dependency on electricity as final form of energy across sectors (given increase in, for instance, electric vehicles and electric cookstoves and heaters) could affect the reliability of the energy system (Guivarch & Monjon, 2015; Hung et al., 2016) (SDG 7.1). The increase in diversity of (clean) energy sources and related infrastructure investments would enhance access to modern energy services (here we defined all low-carbon energy sources as modern) (SDG 7.1), but energy affordability may be affected (SDG 7.1), as indicated under SDG1. Finally, renewable energy sources, are more easily introduced in remote areas, enabling broader electricity access (SDG 7.1) as shown under SDG1. However, if forest protection limits communities access to biomass asa source of energy, this could affect both energy access and the level of renewable energy consumed. Finally, reducing food waste and improving agricultural and livestock productivity would reduce energy demand (Kummu et al., 2012; Schader et al., 2015).

SDG8 – Economic growth and employment

Avoiding high reliance on fossil-fuel industries that are based on finite resources, would prevent possible future economic disruption caused by resource shortage and price volatility, and as such facilitate a sustained economic growth (SDGs 8.1 and 8.3). In that sense, a switch to non-bioenergy CCS technologies, gas and nuclear energy could hamper economic growth in the long run (Fankhauser et al., 2008; Ferroukhi et al., 2016; IPCC, 2014). Sustained economic growth could be enhanced through a switch to renewable energy sources and a decrease in energy demand. Although the costs of mitigation could slow economic growth in the short-term, low-carbon investments are likely to have positive economic effects in the long-term (Fankhauser et al., 2008; Ferroukhi et al., 2016; IPCC, 2014; NCE, 2018). Moreover, sustained economic growth can also be stimulated by an increase in economic productivity (SDG 8.2) and resource efficiency (SDG 8.4) and some climate-change mitigation measures specifically focus on efficiency in production and consumption, such as industrial energy and material use efficiency. However, (BE)CCS increases the use of resources as additional energy is required to run the technology itself, although this additional energy could be considered productive in BECCS by expanding the carbon sink potential. A comparison of economic productivity between fossil fuel and nuclear and renewables is not suitable given the very different types of limited resources and respective impacts. However, low-carbon transition measures more generally contribute to a sustainable economic growth through a decoupling from resource use and related environmental degradation (SDG 8.4) (see impacts described under SDG 3 and SDG 15). However, adequate environmental assessments need to be conducted to ensure potential risks are avoided.

Forest protection and development projects can generate additional income through enabled economic activities such as pollination and tourism (Katila et al., 2017). Moreover, as tree plantations have a higher rate of timber production, afforestation and reforestation projects can stimulate the economy through timber markets (Kibria, 2015). In general, afforestation and reforestation projects would also create new jobs, even if the timber is not sold.

Technological and infrastructure upgrading (SDG 8.2) for improved productivity, reduced waste and low-carbon energy production are stimulated by climate-mitigation measures across all sectors (Bhattacharya et al., 2016; Mattauch et al., 2015). This demand for new technologies and infrastructure would stimulate economic diversification and innovation (SDGs 8.2 and 8.3) for countries that produce related equipment, including BECCS, although fossil fuel CCS, nuclear and gas could lead to lock-in effects into finite resources and limit capitalization on related investments (Bertram et al., 2015; IPCC, 2014).

The net effect of climate-change mitigation on employment probably differs across countries as jobs created in renewables and energy-efficiency sectors may or may not account for all lost jobs in the fossil-fuel industry (in the same country) and workers may not easily switch between sectors (SDGs 8.5). Nonetheless, studies show that, provided sufficient support for job transition, climate-change mitigation would not pose a threat to current employment rates and would likely have a positive impact on job numbers (Babiker & Eckaus, 2007; Fankhauser et al., 2008; Ferroukhi et al., 2016; GEA, 2012; ILO, 2010; IPCC, 2014; Kerr et al., 2016; Tirado Herrero et al., 2011; UKERC, 2014). Furthermore, the transition to a low-carbon economy would likely create many decent jobs (SDGs 8.3 and 8.8) in energy efficiency, urban planning and renewables industries (Höhne et al., 2015; ILO, 2010) and lead to more safe and secure working environments through infrastructure upgrading across sectors and a reduction in occupational accidents related to fossil-fuel extraction and transportation (Markandya & Wilkinson, 2007; Steinsvåg et al., 2008; Sumner & Layde, 2009). Vocational training for skills relevant to a low-carbon transition can support the creation of new (decent and safe) jobs where there is demand (Apeaning & Thollander, 2013; Healy & Barry, 2017; Louie & Pearce, 2016). Support for (BE)CCS, nuclear and hydro-energy poses a risk of work-related accidents in the absence of adequate safety measures, such as high levels of CO2 inhalation, nuclear material leakage and landslide, respectively. However, the risk for nuclear catastrophic events is low. There have been two catastrophic events at nuclear power plants in the past (Chernobyl in 1986 and Fukushima in 2011). In the case of the Fukushima Daiichi accident the doses to the public are generally low or very low and no discernible increased incidence of radiation-related health effects are expected (UNSCEAR, 2013). The

Chernobyl accident resulted in the deaths of 28 power plant employees and fireman from acute radiation syndrome and also in excess thyroid cancers among the public (6000 as of 2006) with a small number of fatalities (15 as of 2005). Nonetheless, current reactor designs have improved in safety and an emergency this severe is not considered possible for running nuclear power plants (IAEA, 2016).

SDG9 – Infrastructure and industrialization

As indicated under SDG8, a low-carbon transition broadly requires investment in reliable, clean, efficient and sustainable infrastructure, retrofitting or closure of old inefficient industries and power plants and infrastructure upgrading (SDGs 9.1, 9.4 and 9.5), as well as a reduction in material and energy demand (SDG 9.4). Such developments would facilitate sustainable industrialization (SDG 9.2) and stimulate innovation and economic diversification (SDG 9.5), as shown under SDG8. However, except for fossil fuel CCS and agricultural measures, climate change mitigation measures take a toll on existing fossil fuel industries, reducing demand for fossil fuels and in some cases, leading to premature closure of fossil fuel power plants. As indicated under SDG8, if policies that facilitate a smooth low-carbon transition are not implemented, climate mitigation measures can lead to negative economic and employment impacts in countries with significant fossil fuel resources and high employment in the sector and would limit inclusive industrialisation (SDG 9.2) (Johnson et al., 2015; McGlade & Ekins, 2015). Similar trade-offs may also be seen in the livestock industry as a result of increased costs and reduced demand (Eory et al., 2017) and in the energy and agricultural industries, provided energy (GHG) and agricultural GHG taxes.

SDG10 – Reducing inequality

Most impacts presented under SDG 1 and SDG 2 are also directly related to SDG 10, in particular with regard to economic improvements for the bottom 40% of the population based on income (SDG 10.1). Measures that affect access to (affordable) basic services and resources or that have impacts in the area of agriculture would disproportionately target the poor as these are more likely to be dependent on those services and resources and to have their incomes affected by changes in prices, costs or access. On a different note, from a participatory perspective, small-scale renewable energy plants can be developed in a way that benefits individuals and communities, hence, increasing inclusiveness in decision-making and benefits sharing of energy production (Kunze & Becker, 2015; Mccollum et al., 2018).

SDG11 – Sustainable cities and communities

Energy efficiency improvements in buildings require high upfront investments that may lead to a short-term increase in housing costs and limit affordability (SDG 11.1), if not subsidised (Cayla & Osso, 2013). However, the resulting energy savings, improved thermal insulation and other benefits related to such upgrading would increase the availability of adequate and safe housing (SDG 11.1) (Ürge-Vorsatz & Tirado Herrero, 2012; Winkler et al., 2002). In addition to housing adequacy, energy access and affordability are key elements in the provision of basic services to communities (SDG 11.1) and may be affected by climate change mitigation measures, as described under SDGs 1 and 7. More energy efficient industries could provide waste heat, waste water and electricity to cities, making them more sustainable (Karner et al., 2016).

Transport-related GHG emissions per person kilometre can be reduced, for instance, by improving planning and infrastructure, by stimulating the use of public transport, cycling and walking, or by tackling fuel efficiency and emissions intensity through use of electric vehicles or biofuels. These measures improve transport sustainability and can expand access to public transport (SDG 11.2) (Bhattacharya et al., 2016; Creutzig et al., 2015; UNSG, 2016). Furthermore, as indicated under SDG3, transport-related climate-change mitigation measures can lead to road safety (SDG 11.2), provided adequate investments in cycling infrastructure and signalling of electric vehicles in low-speed areas.

Cities compactness, energy efficiency and the use of renewables would improve sustainability of human settlements (SDG 11.3) (IPCC, 2014), reduce the environmental impacts of cities (SDG 11.4, see also SDG 15) and improve urban air quality (SDG 11.6). Although the resulting waste from decommissioning of wind turbines (Martínez et al., 2009), and from running power plants and CCS would require additional waste management (SDG 11.6), replacement of coal would reduce radioactive fly and bottom ash waste (Baba, 2002). Moreover, organic municipal waste could be addressed through management of related methane emissions (waste-to-energy systems) (Ayalon et al., 2001; Bogner et al., 2008).

SDG12 – Sustainable consumption & production

Measures for climate-change mitigation addressing consumers through climate-change awareness campaigns, education programs and product-performance labels enhance awareness of sustainable development and related lifestyles (also under SDG4) (SDG 12.8). GHG emissions audits, reporting and monitoring, regulations, fiscal/financial incentives and voluntary agreements are measures that encourage GHG emissions reduction in companies, and hence, improve their sustainability (SDGs 12.2 and 12.6). Similarly, public procurement regulations to support acquisition of low-carbon services and products ensure increased sustainability (SDG 12.7).

Material and energy efficiency, limited resources (e.g. fossil fuels) depletion deceleration, and management of natural resources (e.g. forests), are essential outcomes of GHG emissions reduction measures (SDG 12.2), as shown under SDGs 8 and 9. Nevertheless, replacement of fossil fuels with other energy sources and expansion of EVs can lead to increased demand for rare earth minerals, such as lithium, cobalt, neodymium, palladium, platinum, gallium, dysprosium and other (Buchert et al., 2011). Furthermore, a related outcome of energy and resource efficiency measures is waste reduction (SDG 12.5) that also applies to food waste to address methane emissions (SDG 12.3), as shown under SDG 11, and to waste-to-energy systems. Finally, as shown under SDG3, actions to reduce GHG emissions have a direct impact on air, water and soil pollutants (SDG 12.4).

SDG13 – Climate action

SDG13 concerning climate change covers two major aspects: adaptation and mitigation. As this study focuses on the impacts of climate-change mitigation measures (mainly covered in SDG13.2) on other SDGs, direct synergies and trade-offs with climate change adaptation (SDG13.1 and SDG13.2) are also relevant. For instance, managing, conserving and restoring forests and nature areas to increase carbon sinks also improve adaptation of natural and human habitats (Griscom et al., 2017; Verchot et al., 2007) (SDGs 13.1 and 13.2). Similarly, mitigation practices in agriculture likely lead to more resilient food production systems, although trade-offs could also occur, if biofuels are not sustainably grown, for instance (shown under soil quality in SDG 3) (Aguilera et al., 2013; Smith & Olesen, 2010). Finally, the use of hydropower implies the creation of water reserves which may support adaptation to periods of water scarcity (IPCC, 2014).

The other two targets of SDG13 are also affected by climate mitigation action. All climate change mitigation measures lead to an increase in domestic climate action and integration of climate concerns in national policies (SDG 13.2). Lastly, awareness raising and capacity building through campaigns and trainings are one type of climate action (SDG 13.3).

SDG14 – Life under water

As water bodies around the globe are closely interrelated with oceans, thermal and non-thermal pollution impacts identified under SDG6 would also apply to ocean pollution, even when power plants are not located along the coast (SDG 14.1). However, the economies of countries near marine areas may be stimulated by the use of renewable energy installations, such as off-shore wind turbines and wave and tidal energy conversion, if adequately managed to avoid impacts on ecosystems services (SDG 14.7) (Gilmartin & Allan, 2015; Michler-Cieluch et al., 2009). Conservation of mangrove forests for climate mitigation in themselves support targets of SDG14 (SDG 14.2 and 14.5) and enhance tourism and fish stocks (Joffre et al., 2015; Kibria, 2015; Primavera, 2006; Truong & Do, 2018).

SDG15 – Life on land

As shown under SDG3, most climate-change mitigation measures decrease air pollution and avoid deposition and leakage of pollutants to soil and water bodies. Furthermore, conservation, restoration and sustainable management of the world's ecosystems, such as wetlands, forests, and pastures are important climate-change mitigation measures (SDGs 15.1, 15.2, 15.4, 15.5) (Griscom et al., 2017; Smith et al., 2013; Swart, 2003; van Zeijts et al., 2017). In addition to protect and restore natural areas, adopting sustainable agriculture (e.g. lower use of pesticides and nutrients) (Smith et al., 2013) could expand natural habitats and increase biodiversity (IPCC, 2014) (SDGs 15.4, 15.5).

Furthermore, sustainable agricultural practices to reduce GHG emissions, such as no-tillage and direct seeding, prevent soil degradation and desertification (Smith et al., 2013) (SDG 15.3). Nonetheless, not all agricultural practices are beneficial to ecosystems. For example, large scale monocultures of biofuels can lead to deforestation and reduce habitats and biodiversity (Bonsch et al., 2016; Davis et al., 2013; Dias de Oliveira et al., 2005; Finco & Doppler, 2010; von Blottnitz & Curran, 2007). An integration of crops and livestock can reduce environmental impacts, support soil quality and enhance biological diversity as compared to monocultures (Lemaire et al., 2014; Viaud et al., 2018).

Other forms of renewable energy production could also lead to biodiversity trade-offs. For instance, hydropower and tidal/wave energy may substantially change natural habitats and ecosystems (SDGs 15.4 and 15.5) (Gill, 2005; Inger et al., 2009; IPCC, 2014; Neill et al., 2012). Wind turbines could also have significant impact on the bird populations in the vicinity (Schippers et al., 2020). However, in-depth local environmental assessments are necessary to determine net impacts compared to replaced fossil fuels (Athanas & McCormick, 2013; Rybach, 2003; Shortall et al., 2015; Sliz-Szkliniarz, 2013) (SDGs 15.1, 15.4 and 15.5). Rooftop solar PV and wind are likely to be the most benign of energy sources and would likely have a positive overall impact on ecosystems (S. A. Abbasi & Abbasi, 2000). Improved efficiency of cookstoves and heating with biomass can reduce deforestation for timber (Gebreegziabher et al., 2017; Mehetre et al., 2017; ver Beek et al., 2020). On the contrary, fossil fuel CCS would increase demand for fossil fuels and related trade-offs (but will reduce some air pollutants). Finally, CCS, BECCS and nuclear pose risks of CO2, nutrients and radioactive leakage, as previously discussed, but such risks are likely minor compared to potential negative impacts of fossil-fuel use and related upstream activities (see also SDG 3).

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Supplementary Material Chapter 6

CBD, UNFCCC and UNEA documents included in the analysis

1. United Nations Convention on Biodiversity

Key overarching agreement:

- Convention on Biological Diversity (adopted in 1992; effective from 1993)

The text of the convention can be accessed under https://www.cbd.int/convention/text/.

Key decisions before 2015:

- UNEP/CBD/COP/DEC/IX/2 Agricultural biodiversity: biofuels and biodiversity (2008)
- UNEP/CBD/COP/DEC/X/2 The Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets (2010)UNEP/CBD/COP/DEC/X/10 National reporting: review of experience and proposals for the fifth national report (2010)
- UNEP/CBD/COP/DEC/X/33 Biodiversity and climate change (2010)
- UNEP/CBD/COP/DEC/X/37: Biofuels and biodiversity (2010)
- UNEP/CBD/COP/DEC/XI/19 Biodiversity and climate change related issues: advice on the application of relevant safeguards for biodiversity with regard to policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (2012)

Key decisions COP13 (2016):

- UNEP/CBD/COP/DEC/XIII/1 Progress in the implementation of the Convention and the Strategic Plan for Biodiversity 2011-2020 and towards the achievement of the Aichi Biodiversity Targets
- UNEP/CBD/COP/DEC/XIII/2 Progress towards the achievement of Aichi Biodiversity Targets 11 and 12

- UNEP/CBD/COP/DEC/XIII/3 Strategic actions to enhance the implementation of the Strategic Plan for Biodiversity 2011-2020 and the achievement of the Aichi Biodiversity Targets, including with respect to mainstreaming and the integration of biodiversity within and across sectors
- UNEP/CBD/COP/DEC/XIII/4 Biodiversity and climate change
- UNEP/CBD/COP/DEC/XIII/5 Ecosystem restoration: short-term action plan
- UNEP/CBD/COP/DEC/XIII/7 Forest biodiversity: the role of international organizations in supporting the achievement of the Aichi Biodiversity Targets
- UNEP/CBD/COP/DEC/XIII/11 Voluntary specific workplan on biodiversity in cold-water areas within the jurisdictional scope of the Convention
- UNEP/CBD/COP/DEC/XIII/14 Climate-related geoengineering
- UNEP/CBD/COP/DEC/XIII/23 Capacity-building, technical and scientific cooperation, technology transfer and the clearing-house mechanism
- UNEP/CBD/COP/DEC/XIII/24 Cooperation with other conventions and international organizations
- UNEP/CBD/COP/DEC/XIII/31 Key scientific and technical needs related to the implementation of the Strategic Plan for Biodiversity 2011-2020 and related research

Key decisions COP14 (2018):

- CBD/COP/DEC/14/1 Updated assessment of progress towards selected Aichi Biodiversity Targets and options to accelerate progress
- CBD/COP/DEC/14/2 Scenarios for the 2050 Vision for Biodiversity
- CBD/COP/DEC/14/3 Mainstreaming of biodiversity in the energy and mining, infrastructure, manufacturing and processing sectors
- CBD/COP/DEC/14/5 Biodiversity and climate change
- CBD/COP/DEC/14/8 Protected areas and other effective area-based conservation measures
- CBD/COP/DEC/14/22 Resource mobilization
- CBD/COP/DEC/14/24 Capacity-building and technical and scientific cooperation

- CBD/COP/DEC/14/27 Process for aligning national reporting, assessment and review
- CBD/COP/DEC/14/28 Tools to evaluate the effectiveness of policy instruments for the implementation of the Strategic Plan for Biodiversity 2011-2020
- CBD/COP/DEC/14/30 Cooperation with other conventions, international organizations and initiatives
- CBD/COP/DEC/14/36 Second work programme of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

All CBD COP decisions can be accessed under https://www.cbd.int/decisions/cop/.

Other:

- CBD/WG2020/2/3 Zero Draft of the post 2020 Global Biodiversity Framework
- CBD/WG2020/2/L.1 Draft report [of the second meeting of the Open-ended Working Group on the post 2020 Global Biodiversity Framework; Rome, 24-29 February 2020]

CBD documents on the preparation of the post 2020 Global Biodiversity Framework can be accessed under https://www.cbd.int/conferences/post2020/wg2020-02/documents.

2. United Nations Framework Convention on Climate change

Key overarching agreements:

- United Nations Framework Convention on Climate Change, FCCC/INFORMAL/84 (adopted in 1992; effective from 1994), Accessible at https://unfccc.int/resource/docs/convkp/conveng.pdf
- Kyoto Protocol (adopted in 1997; effective from 2005), Accessible at https://unfccc.int/resource/docs/convkp/kpeng.pdf
- Copenhagen Accord (agreed on in 2009), FCCC/CP/2009/11/Add.1, Decision 2/CP.15, Accessible at https://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf
- Paris Agreement (adopted in 2015; effective from 2016), Accessible at https://unfccc.int/sites/default/files/english_paris_agreement.pdf
- Katowice Climate Conference Decisions (December 2018):

- FCCC/CP/2018/10/Add.1&2 Report of the Conference of the Parties on its twenty-fourth session, held in Katowice from 2 to 15 December 2018, Accessible at https://unfccc.int/event/cop-24
- FCCC/PA/CMA/2018/3/Add.1&2 Report of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement on the third part of its first session, held in Katowice from 2 to 15 December 2018, Accessible at https://unfccc.int/event/cma-1-3
- FCCC/KP/CMP/2018/8/Add.1 Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol on its fourteenth session, held in Katowice from 2 to 15 December 2018, Accessible at https://unfccc.int/event/cmp-14

- Madrid Climate Conference Decisions (December 2019):
  - FCCC/CP/2019/13/Add.1&2 Report of the Conference of the Parties on its twenty-fifth session, held in Madrid from 2 to 15 December 2019 (https://unfccc.int/event/cop-25)
  - FCCC/PA/CMA/2019/6/Add.1 Report of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement on its second session, held in Madrid from 2 to 15 December 2019 (https://unfccc.int/event/cma-2)
  - FCCC/KP/CMP/2019/8/Add.1 Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol on its fifteenth session, held in Madrid from 2 to 15 December 2019 (https://unfccc.int/event/cmp-15)

Key decisions addressing land-use, land-use change and forestry:

- FCCC/CP/2001/13/Add.1, Decision 11/CP.7 Land use, land-use change and forestry
- FCCC/CP/2003/6/Add.1, Decision 13/CP.9 Good practice guidance for land use, land-use change and forestry in preparation of national greenhouse gas inventories
- FCCC/CP/2005/5/Add.2, Decision 14/CP.11 Tables of the common reporting format for land use, land-use change and forestry
- FCCC/CP/2007/6/Add.1, Decision 2/CP.13 Reducing emissions from deforestation in developing countries: approaches to stimulate action

- FCCC/CP/2009/11/Add.1, Decision 4/CP.15 Methodological guidance for activities relating to reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
- FCCC/CP/2010/7/Add.1, Decision 1/CP.16 The Cancun Agreements: Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention
- FCCC/CP/2011/9/Add.1, Decision 2/CP.17 Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention
- FCCC/CP/2011/9/Add.2, Decision 12/CP.17 Guidance on systems for providing information on how safeguards are addressed and respected and modalities relating to forest reference emission levels and forest reference levels as referred to in decision 1/CP.16
- FCCC/CP/2012/8/Add.1, Decision 1/CP.18 Agreed outcome pursuant to the Bali Action Plan
- FCCC/CP/2013/10/Add.1, Decision 9/CP.19 Work programme on results-based finance to progress the full implementation of the activities referred to in decision 1/CP.16, paragraph 70
- FCCC/CP/2013/10/Add.1, Decision 10/CP.19 Coordination of support for the implementation of activities in relation to mitigation actions in the forest sector by developing countries, including institutional arrangements
- FCCC/CP/2013/10/Add.1, Decision 11/CP.19 Modalities for national forest monitoring systems
- FCCC/CP/2013/10/Add.1, Decision 12/CP.19 The timing and the frequency of presentations of the summary of information on how all the safeguards referred to in decision 1/CP.16, appendix I, are being addressed and respected
- FCCC/CP/2013/10/Add.1, Decision 13/CP.19 Guidelines and procedures for the technical assessment of submissions from Parties on proposed forest reference emission levels and/or forest reference levels
- FCCC/CP/2013/10/Add.1, Decision 14/CP.19 Modalities for measuring, reporting and verifying
- FCCC/CP/2013/10/Add.1, Decision 15/CP.19 Addressing the drivers of deforestation and forest degradation

- FCCC/CP/2015/10/Add.3, Decision 16/CP.21 Alternative policy approaches, such as joint mitigation and adaptation approaches for the integral and sustainable management of forests
- FCCC/CP/2015/10/Add.3, Decision 17/CP.21 Further guidance on ensuring transparency, consistency, comprehensiveness and effectiveness when informing on how all the safeguards referred to in decision 1/CP.16, appendix I, are being addressed and respected
- FCCC/CP/2015/10/Add.3, Decision 18/CP.21 Methodological issues related to non-carbon benefits resulting from the implementation of the activities referred to in decision 1/CP.16, paragraph 70
- FCCC/CP/2017/11/Add.1, Decision 4/CP.23 Koronivia joint work on agriculture

All UNFCCC COP decisions can be accessed (by typing the decision number in the 'Decision symbol' search field without special symbols (e.g. 1cp18 instead of 1/cp.18)) at https://unfccc.int/decisions

3. United Nations Environmental Assembly

Ministerial declarations

- Ministerial outcome document of the first session of the United Nations Environment Assembly of the United Nations Environment Programme, UNEA-1, 27 June 2014
- 'Towards a pollution-free planet', Ministerial declaration of the United Nations Environment Assembly at its third session, UNEA-3, 4-6 December 2017
- 'Innovative solutions for environmental challenges and sustainable consumption and production'
- Ministerial declaration of the United Nations Environment Assembly at its fourth session, UNEA-4, 11-15 March 2019

Resolutions

- 'Ecosystem-based adaptation', UNEA Res, 1/8, 23-27 June 2014
- 'Supporting the Paris Agreement', UNEA Res. 2/6, 23-27 May 2016
- 'Sustainable consumption and production', UNEA Res. 2/8, 23-27 May 2016
- 'Sustainable management of natural capital for sustainable development and poverty eradication' UNEA Res. 2/13, 23-27 May 2016

- 'Sustainable coral reef management', UNEA Res. 2/12, 23-27 May 2016
- 'Mainstreaming of biodiversity for well-being', UNEA Res. 2/16, 23-27 May 2016
- 'Enhancing the work of the United Nations Environment Programme in facilitating cooperation, collaboration and synergies among biodiversity-related conventions', UNEA Res. 2/17, 23-27 May 2016
- 'Relationship between the United Nations Environment Programme and the multilateral environmental agreements for which it provides the secretariats', Res. 2/18, 23-27 May 2016
- 'Pollution mitigation by mainstreaming biodiversity into key sectors', UNEA Res. 3/2, 4-6 December 2017
- 'Environment and health', UNEA Res. 3/4, 4-6 December 2017
- 'Investing in innovative environmental solutions for accelerating the implementation of the Sustainable Development Goals', UNEA Res. 3/5, 4-6 December 2017
- 'Managing soil pollution to achieve sustainable development', UNEA Res. 3/6, 4-6 December 2017
- 'Innovative pathways to achieve sustainable consumption and production', UNEA Res. 4/1, 11-15 March 2019
- 'Innovation on biodiversity and land degradation', UNEA Res. 4/10, 11-15 March 2019
- 'Sustainable management for global health of mangroves', UNEA Res. 4/12, 11-15 March 2019
- 'Sustainable coral reefs management', UNEA Res. 4/13, 11-15 March 2019
- 'Conservation and sustainable management of peatlands', UNEA Res. 4/16, 11-15 March 2019

UNEP reports

- 'Relationship between the United Nations Environment Programme and multilateral environmental agreements' UNEP/EA.1/INF/8, 30 May 2014

All UNEA documents can be accessed at https://environmentassembly.unenvironment.org/

Summary

Despite decades of international climate negotiations, cumulative worldwide climate-action pledges still fall short of the needed effort to keep the maximum global mean temperature increase well below 2°C and to further strive for a maximum of 1.5°C, as established in the Paris Agreement. This Agreement ensures that all developed and developing countries are engaged in climate action. Yet, its bottom-up and voluntary approach means that the ambition of climate action is determined by sovereign countries and possibilities to influence their decisions are limited. Hence, understanding what enables and what discourages climate action and how to use these levers to boost ambition is key to the implementation of the Paris Agreement.

While multiple climate-action enablers have been identified and studied in the past, four important research gaps remained at the start of my PhD. **First**, international climate-change negotiations are meant to stimulate domestic climate action, but the actual effect of key international climate moments on domestic policy adoption had not yet been studied. **Second**, countries' climate-action pledges under the Paris Agreement are meant to be in line with countries' capabilities and responsibility. Yet, how countries' development contexts influence their international pledges and how these pledges compare across countries of similar development contexts were not analysed. **Third**, some international climate-action pledges are conditional on international assistance and providing such assistance likely is crucial to achieving the Paris Agreement. However, the question remained whether climate finance is proportionately targeting countries with higher conditional greenhouse-gas (GHG) emissions-reduction pledges and whether this finance matches recipients' interests for mitigation or adaptation action. Moreover, the alignment of climate finance with recipient countries' priorities deserved studying, as it influences recipients' perceived ownership and supports a more efficient use of limited resources. **Finally**, potential negative effects of climate-change action on development have always been the main invoked obstacle to more ambitious action. Nonetheless, climate-change action likely also leads to multiple co-benefits. Identifying negative and positive effects of climate action on other development areas and learning how to harness them for greater climate-change and sustainable-development action ambition is key to better integrate national and international policy processes.

My PhD research **aims to address these research gaps on major climate-change action enablers and to explore how these enablers have performed over time and across countries.** Moreover, it **aims to develop research and policy-making**

tools to further analyse these enablers and to leverage their potential to boost climate-change action. The major enablers that I address in my thesis, are: key moments in international climate negotiations; country contexts and the common but differentiated responsibilities and respective capabilities (CBDR-RC) principle; international climate assistance; and policy coherence for the joint implementation of climate targets and the sustainable development goals (SDGs). In this context, I discuss four policy coherence types: coherence between national and international action; coherence between sources of finance; socio-economic and environmental coherence; and coherence between international policy agendas.

In Chapter 2, I and my collaborators (hereafter referred to as 'we') explore how international climate negotiations have influenced the adoption of national climate strategies, legislation and targets during the period 2007-2017. We found that momentum around the Copenhagen Accord and the Paris Agreement led to a stronger adoption of national strategies and legislation, and of GHG-emissions reduction targets, respectively. In general, developed countries and high GHG emitters have been the first movers in climate action. The number of countries with national climate legislation and strategies increased from 20% in 2007 to 70% in 2017, with a quick growth up to 2012 and a subsequent levelling-off. On the other hand, GHG-emissions reduction targets were only adopted by less than a quarter of countries until 2015, when the coverage grew to three quarters in the build-up to the Paris Agreement. Renewable energy targets adoption has grown steadily and now matches the share of countries with GHG-emissions reduction targets. In contrast, energy-efficiency targets are only adopted by about a third of countries.

In Chapter 3, we analyse how countries' development contexts influence their pledged GHG-emissions reductions to 2030. To that end, we standardized the GHG emissions reduction targets of 109 countries and compared these targets to each other relative to several key development indicators that countries use themselves to reflect countries' responsibilities and capabilities: Gross Domestic Product (GDP) per capita; historical and annual GHG per cap; GHG per GDP; trends in GHG per capita and in GDP per capita; fossil fuel dependence; and climate-relevant international financial support received. We found that countries with higher GDP per capita and higher historical and annual GHG per capita tend to pledge higher GHG emissions reductions per capita by 2030 relative to 2010. Nonetheless, we observed that some countries with high fossil fuel dependency pledge much lower GHG emissions reductions relative to other countries in a similar GDP category and historical or annual GHG emissions per capita. No correlation was found between past climate-relevant official financial assistance (ODA) received and conditional GHG emissions reduction pledges. Importantly, while updated Nationally Determined Contributions

(NDCs) presented in 2020 were expected to present higher GHG-emissions reductions, we found that many countries maintain the same targets or even pledge lower GHG-emissions reductions than in their initial NDC.

In Chapter 4, we take the analysis of climate-relevant finance one step further and explore how this finance was distributed across development areas and across climate-change action types (i.e. mitigation versus adaptation). We categorized climate-relevant ODA committed between 2010-2018 based on the SDGs and analysed what share of finance and of individual transactions were allocated to each SDG. We compare these findings with the NDC-SDG Connections database, which categorizes NDC activities by SDGs. We find that the distribution of climate-relevant ODA across the SDGs mostly matches that of the recipient countries' NDC activities, but the correlation between the two did not improve in the post-Paris period (2016-2018), relative to the pre-Paris period (2010-2015). Moreover, we find that donors focus strongly on climate change mitigation, while recipients propose more adaptation measures. The balance between mitigation and adaptation climate-relevant ODA became more even in the post-Paris period, but mitigation remains the focus of donors.

In Chapter 5, we go beyond the immediate links of climate-change action to the SDGs and further analyse the positive and negative effects of specific climate-change mitigation measures on the SDGs. Moreover, we analyse countries' context dimensions that influence the occurrence and magnitude of climate-change mitigation measures effects. We find that climate-change mitigation action affects all SDGs positively and negatively. Energy efficiency, reduced demand for energy services and a switch to renewable energy mostly lead to positive effects on many SDGs. However, bioenergy, carbon capture and storage and nuclear energy negatively affects several SDGs. The choices of project location and of approaches in implementation were the most common dimensions that influence the occurrence and magnitude of positive and negative effects on SDGs. Addressing these dimensions through policy design and policy mixes would help to enhance positive effects and to reduce negative effects of climate-change mitigation action. In Chapter 5 we provide several suggestions of how each dimension can be tackled.

In Chapter 6, we apply the concept of climate-development interlinkages in an international setting by analysing how UNFCCC and CBD address the impacts of action in one area on the other and the common drivers of climate change and biodiversity loss. We found that both agendas acknowledge their interlinkages and refer to each other's topics, but important areas and trade-offs remain unaddressed. For instance, important carbon sinks (and potential sources) such as wetlands and marine and coastal ecosystems, are mostly ignored. Additionally, concrete measures on major sectors, such as agriculture, are missing. Finally, we found that, although common drivers are largely addressed, important gaps remain, in particular, concerning trade and urbanization.

Finally, in Chapter 7, I discuss the studied major enablers of climate-change action and show that my research objectives were achieved. Moreover, I provide further research and policy recommendations based on the findings of previous chapters. Maintaining the international climate momentum generated with the Paris Agreement adoption is essential. Researchers need to further explore climate-change action enablers, how they perform and how they can be engaged. To reach the Paris Agreement goals, climate ambition needs to be raised. To that end, countries need to be able to compare and to learn from one another, climate finance allocations need to better reflect recipients' priorities and needs, and policy coherence must be enhanced nationally and internationally across different areas of sustainable development. Key recommendations for UNFCCC processes are: increased comparability of countries NDCs, improved transparency, reporting on climate-SDGs interlinkages and on trade-offs considerations, and improved reporting standards.

My PhD thesis advanced the scientific understanding of climate-change action enablers and provides tools for further research and policy making. In particular, the tools allow researchers and relevant stakeholders to 1) compare the ambition of countries' climate pledges in a development context; 2) better align climate and sustainable development finance; 3) make use of an overview of climate and SDG interactions and of opportunities for enhanced policy coherence; and 4) assess gaps and opportunities for a better integration of the international climate and biodiversity agendas. From a policy perspective, our climate-change action assessments likely facilitate comparability and support policy makers to design better measures that maximize synergies and minimize trade-offs between climate and sustainable development actions. Overall, my findings and recommendations likely enable more ambitious climate action, when applied.

About the author

Gabriela I. Iacobuţă was born on 16th February 1989 in the small town of Găeşti, Romania. She pursued a Physics degree at Nottingham University, United Kingdom to follow her passion for Astronomy. During her studies, she did volunteer work in the United Kingdom and Tanzania, an internship at the National Institute for Astrophysics, Optics and Electronics in Mexico and a summer fellowship at the Australian Astronomical Observatory in Australia, co-authoring two peer-reviewed journal articles in Astrophysics. During her 2012 summer in Australia, Gabriela's concern for environmental issues grew stronger. Not only did the Earth Summit Rio+20 fall short of expectations for bold environmental action, but Gabriela also observed the palpable impacts of climate change and environmental degradation all around her - just off the Western coast of Australia, corals were quickly dying in the Great Barrier Reef. Called to action, in 2013 she finished her Physics degree, First Class with Honours, and moved her focus to Wageningen University's MSc Environmental Sciences (Environmental Economics track) and MSc Climate Studies (Environmental Systems Analysis track), earning cum laude for the latter. During this time, she engaged with both theory and praxis by conducting internships at UNU-EHS, UNFCCC, and NewClimate Institute. At the end of her studies in 2016, Gabriela joined CD-LINKS, an EU-funded project on climate and sustainable development at Wageningen University and prepared a PhD proposal and two papers. Given her strong policy interest and the policy relevance of her PhD research, Gabriela obtained a research position at the German Development Institute (DIE) in Bonn in 2018, where she has since continued her research alongside policy advise and training, through various publicly-funded projects.

Today, in 2021, Gabriela is not only happy to have finalized her PhD thesis, but also to see part of it contributing to the Sixth Assessment Report of the IPCC, and to be able to give back to the research community as a special issue guest editor for the Journal of Integrative Environmental Sciences. Importantly, she is grateful to be able to put her photography passion to work by sharing with you some of the world's beauty that she's witnessed and that is, unfortunately, affected by climate change. She hopes that, given enough awareness, the world will come together to preserve its richness.

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Bauer, S., Kurdziel, M.-J., **Iacobuta, G.I.**, Brandi, C., Rodríguez, J.C., Deryng, D., Hanshom, J., Höhne, N., Smit, S., Srigiri, S. (2021). Working together to achieve the Paris climate goals and sustainable development: international climate cooperation and the role of developing countries and emerging economies, German Development Institute (DIE) and NewClimate Instituete, Bonn/Cologne, Germany

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The Netherlands research school for the
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(SENSE) declares that

Gabriela Ileana Iacobuţă

born on 16 February 1989, in Găeşti, Romania

has successfully fulfilled all requirements of the
educational PhD programme of SENSE.

Wageningen, 29 November 2021

Chair of the SENSE board

Prof. dr. Martin Wassen

The SENSE Director

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K O N I N K L I J K E N E D E R L A N D S E
A K A D E M I E V A N W E T E N S C H A P P E N

The SENSE Research School declares that **Gabriela Ileana Iacobuţă** has successfully fulfilled all requirements of the educational PhD programme of SENSE with a work load of 47.2 EC, including the following activities:

SENSE PhD Courses

- Environmental research in context (2016)
- Research in context activity: 'The role of EU external action to jointly address climate and sustainable development (two policy briefs, one blogpost and one event)' (2021)

Selection of Other PhD and Advanced MSc Courses

- Scientific publishing, Wageningen Graduate Schools (2016)
- Reviewing scientific papers, Wageningen Graduate Schools (2016)
- Science communication, Scientific visualisation and graphic representation, Media communication and outreach & Public speaking, German Development Institute (2019)
- The Paris Agreement on Climate Change as a Development Agenda, United Nations System Staff College (2018)
- Multilateral Environmental Agreements, University of Eastern Finland and UN Environment (2019)

Management and Didactic Skills Training

- Co-organized expert workshops: 'NDC-SDG interlinkages in Vietnam' (2018) & 'Fit for purpose? Revitalizing climate and sustainability issues in the G20 process' (2019)
- Guest editor for the special issue „Integrative approaches to the environmental and socio-economic SDGs“ of the Journal of Integrative Environmental Sciences (ongoing)
- Supervising four MSc students with thesis and two with internships (2016-2019)
- Teaching in the MSc courses 'Pollution management' and 'Introduction to Global Change' (2016-2020)
- Four postgraduates/professionals workshops on climate action and the SDGs (2019)

Selection of Oral Presentations

- *Good practice policies for climate change mitigation*. International Conference for Sustainable Development, 24-25 September 2019, New York, United States of America
- *The role of EU's external cooperation in boosting ambitious and coherent climate action*, EU Pavilion at climate COP25, 11 December 2019, Madrid, Spain
- *Just transition as a synergic solution – The cases of South Africa, the Philippines and Germany*. High-Level Political Forum, „Paris minus the SDGs: a formula for inequality?“ side event, 9 July 2020, Online
- *Aligning climate and sustainable development finance through an SDG lens*, Earth Systems Governance Brastislava Conference, 8th September 2021, Online

SENSE coordinator PhD education

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