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Seeing the Carbon Beyond the Trees: Evaluating the Land use, Land-use Change, and Forestry (LULUCF) pledges in countries' Nationally Determined Contributions.

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ABSTRACT OF THESIS submitted by:
Carly SOO for the degree of Master of Science and entitled: Seeing the Carbon Beyond the Trees: Evaluating the Land use, Land-Use Change, and Forestry (LULUCF) pledges in countries' Nationally Determined Contributions.

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The Nationally Determined Contributions (NDCs), submitted as part of the Paris Agreement provide an opportunity to assess countries' climate actions and ambitions. An important sector is land use, land use change and forestry (LULUCF), acting as both a sink and source of emissions. The LULUCF sector is expected to make a significant contribution to helping countries meet their mitigation targets and is included in most NDCs. This research assesses 166 NDCs to understand how countries have treated the LULUCF sector and in turn examines how the national circumstances and capabilities of countries shape their specific mitigation policies. Using approaches from forest transition literature and comparative environmental politics, this research aims to contribute to understanding how the national circumstances and capabilities that may explain variation in climate commitments between countries. It finds general linkages between how countries treat LULUCF targets within their NDCs in accordance with their stage in forest transitions and their national economic structure, however, also recommends further analysis to strengthen these findings.

Keywords: Nationally Determined Contributions; Land use, Land use change and forestry; forest transitions, national circumstances; the Paris Agreement.

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This thesis is dedicated to the successful negotiation of a common accounting framework for the land sector in the post-2020 period.

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Introduction

The post-2020 climate change commitments, known as Nationally Determined Contributions (NDCs), submitted by countries as part of the Paris Agreement offer a new opportunity to assess individual countries climate actions. As well as the chance to estimate their collective impact towards achieving the mitigation goals of the Paris Agreement, NDCs also provide the opportunity to examine the national circumstances that motivate countries to use specific mitigation policies.

An important sector in NDCs is the land use, land use change and forestry sector, also referred to as the LULUCF sector. The LULUCF sector includes land-use activities such as planting trees and the conversion of forestland into agricultural land. As well as a source of greenhouse gas (GHG) emissions, LULUCF activities also act as a sink - absorbing C02 from the atmosphere through the accumulation of carbon in vegetation and soils in terrestrial ecosystems, making LULUCF an important and unique sector in climate mitigation. The LULUCF sector is expected to make a significant contribution to reducing countries' total emissions and is included in most NDCs.

However, the sector is often regarded as a secondary mitigation option or excluded from projections of post-2020 commitments. This is due to the large uncertainties associated with LULUCF emissions, the availability of reliable data, and the mitigation priority of reducing emissions from the energy and industrial sectors. Countries have included LULUCF into NDCs in diverse ways, making it complex to understand the collective impact of climate efforts. In order to track progress towards achieving the goals of the Paris Agreements, it is essential to understand the LULUCF contributions in NDCs. This research evaluates the LULUCF components of NDCs, with a broad aim to understand what and how the national circumstances and capabilities of countries drive their international obligations.

1.1. Background

The Paris Agreement recognizes the role of forests and land use as "a potential game changer for land-use mitigation" (Grassi 2017). Article 5 of the Agreement requires that countries "*should take action to conserve and enhance sinks and reservoirs, including forests*" (Article 5.1).

The importance of the land sector in reducing overall GHG emissions is also broadly indicated by the mitigation goal. The Agreement calls for a "*peaking of GHG emissions…as soon as possible*" to be achieved through "*a balance between anthropogenic emissions by*

*sources and removals by sink*s", and in accordance with "*the best available science*" (Article 4.1). This suggests that LULUCF activities, specifically its role as carbon sink, will continue to play an important role in the future.

Research asserts that significant contributions from the LULUCF sector are required to meet the goals of the Paris Agreement (Grassi et al. 2017). While emissions from the LULUCF sector are a small part of global GHG emissions, estimated between 6-17% of total CO_2 emissions (Le Quéré et al. 2015), land-based mitigation policies could make a significant contribution to achieving national emissions reductions targets. The sector is estimated to contribute between 20-25% of total emissions reductions in countries pledged mitigation targets (Forsell et al. 2016; Grassi et al. 2017).

Using LULUCF activities for emission reductions is an important strategy for many countries to meet their mitigation targets. As evidenced by the content and form of NDCs, many significant emitters such as Russia and Brazil rely on the LULUCF sector as the core component for their emission reductions. Another example is Indonesia where around 60% of GHG emissions are from LULUCF, mostly from deforestation and peat fires (Republic of Indonesia 2016). Indonesia's NDC addresses LULUCF emissions through its Forestry moratorium policy, which prohibits clearing and conversion of primary forests and peatlands in forest estates. it is estimated the impact of this single policy translates to the protecting an area nearly twice the size of Japan, and potentially reducing the rate of deforestation (Wijaya et al. 2017).

1.2. Problem definition

NDCs represent the individual climate efforts of countries, who determine their targets in accordance to their own national circumstances and respective capacities. NDCs offer a new opportunity to assess, compare and track the climate actions that countries intend to pursue in the post-2020 period. However, whether such actions and ambitions are economically or politically feasible is not always clear. In order to understand the feasibility of climate efforts, it is important to examine national circumstances and capabilities that motivate countries to use specific policies, that in turn shape their international commitments. As NDCs reflect national circumstances and capabilities, assessing such circumstances can allow us to evaluate whether countries are making bold or ambitious policy choices or whether they are making choices that are closer to the business as usual pathway. This, in turn, helps to develop better understanding of the likelihood that countries are able to meet their NDCs and increase their ambitions over time.

While these questions warrant a broad examination, my research will specifically focus on evaluating the national circumstances and capabilities with respect to countries' LULUCF commitments. Despite the mitigation potential of LULUCF, the sector is often considered as a subordinate mitigation option in the UNFCCC (Grassi 2017). However under the Paris Agreement land-based mitigation measures, especially the role of forests as a potential carbon sink, is promoted and placed as a key strategy for countries to meet climate targets. Although NDC literature predominantly focuses on decarbonisation of the energy sector, most countries have included the LULUCF sector in their mitigation targets. However, there is range of coverage and approaches used, which makes understanding the aggregate impact of NDCs difficult. Understanding why and how countries choose to include LULUCF helps to understand their national priorities, circumstances and capabilities.

1.3. Research Aim and Objectives

The aim of this research is to assess the LULUCF pledges in NDCs to contribute to understanding the national circumstances and capabilities that may explain variation in climate commitments between countries.

There are two main research objectives:

1. Assess and categorise all countries in accordance with the way they treat LULUCF emissions in their NDCs;
2. Explore the circumstances that potentially explain the treatment of LULUCF in NDCs in countries representing the identified categories.

These objectives are achieved in two steps. I first review all available NDCs to classify them into three groups according to the treatment of LULUCF. At the second stage I use both NDCs and additional evidence to link the treatment of LULUCF in selected countries' NDCs to their national circumstances and capabilities. By examining the LULUCF components in NDCs, I aim to gain insights into the motivations and the national circumstances and capabilities that drive a countries climate change commitments in relation to the land sector.

Understanding the national circumstances that behind countries climate actions can provide us with an indication about the future impact of NDCs and likelihood that countries will achieve their targets and increase their level of ambition. Questions such as how national circumstances and capacities influence the international commitment and the level of ambition (Victor 2011) are important to understand. The focus on LULUCF is particularly important because this sector is often overlooked in terms of its potential impact and opportunity. There are often conflicting and complex arguments using a political and

technical perspective to either justify or caution using the LULUCF sector in climate mitigation (Dooley and Gupta 2017; Federici, Lee, and Herold 2017).

This research relates to broader question of why do some countries implement and use certain mitigation policies, namely the land-use sector, over others. It builds upon the growing literature on LULUCF in NDCs as well as the use of land-based sinks as mitigation policies. It also uses approaches from literature on linking climate policies and national circumstances, especially on how much and why national climate policies vary due to different national circumstances or priorities.

1.4. Outline of thesis

The outline of this thesis is as follows:

- Chapter 2 introduces the LULUCF sector, assesses the existing literature on LULUCF and NDCs, and outlines the research gap that this research aims to address.
- Chapter 3 outlines the scope of the research, and introduces the relevant theories, analytical framework and methodology, including the data sources I use.
- Chapter 4 presents the general results of the different types of NDCs and findings related to the geography, emissions level and income of different groupings; and the detailed results on the specific LULUCF groupings.
- Chapter 5 discusses the results in relation to the research objective and analytical framework; and
- Chapter 6 provides overall conclusions and recommendations of this research.

2. Literature review

The purpose of this literature review is to provide a general overview of the literature on LULUCF and NDCs, justify why the LULUCF sector should be assessed and identify the relevant gaps in the literature that my research aims to address.

In this literature review, I have included scientific reports and working papers as well as scholarly journal articles. Most of the relevant literature on LULUCF and NDCs centers on how the sector could help countries achieve emission reduction targets and contribute to the goals of the Paris Agreement. Literature specifically highlights the potential of the LULUCF sector for climate mitigation and in helping to achieve the transition to a low-carbon future. However, opinion diverges on the extent that LULUCF activities, including biological sinks[1] should be used; many emphasise its significant potential in helping reduce GHG emissions, while some scholars cautioning overreliance on land-based mitigation policies. This is due to the large uncertainties associated with estimating emissions and sinks from the sector and concerns that countries will use biological sinks as way to delay long-term efforts to reduce fossil fuel use. In order to reduce the large uncertainties in the sector, researchers reinforce the need for further scientific research and greater transparency for national accounting. This chapter concludes by stating that in order to understand the long-term impacts of NDCs and their uncertainties, attention should be paid to the national circumstances that drive a country to include or exclude LULUCF in its mitigation pledges.

The chapter briefly defines LULUCF, before presenting the literature on the LULUCF sector, specifically its role in climate mitigation targets. This chapter starts with summarizing the NDCs and defining LULUCF followed by the review of literature on LULUCF structured around two main themes: the importance of LULUCF for climate mitigation and the difficulties and uncertainties in estimating the LULUCF impact.

2.1. LULUCF and the Paris Agreement

The Paris Agreement commits countries to limit the “increase in global average temperature to well below 2 °C above pre-industrial levels” and to pursue efforts to limit the increase to 1.5^0C, acknowledging that this would “significantly reduce the risks and impacts of climate change” (Article 2.1(a) (UNFCCC 2015a). In order to achieve these long-term temperature

[1] The UNFCCC recognizes any activity, process or mechanism that removes GHG from the atmosphere as a sink. Human-induced activities impact terrestrial sinks (Aalde et al. 2006; IPCC 2000)

goals, the Agreement requires decarbonization of the global economy before the end of the century; calling for a “peaking of GHG … as soon as possible” to be achieved through “a balance between anthropogenic emissions by sources and removals by sinks” and in accordance with “the best available science” (Article 4.1). The pace of this transition will be largely determined by the mitigation pledges made by countries in their Nationally Determined Contributions (NDCs).

The Paris Agreement places obligations on all countries to submit NDCs, which outline the goals and strategies to reduce greenhouse gas (GHG) for the post-2020 period. As of June 2018, 170[2] Parties have submitted their first NDCs. NDCs form the core component of a mitigation commitment by communicating the country’s national mitigation targets and actions. Countries determine their own targets in accordance to their own national circumstances and respective capacities and are also subject to a robust transparency framework to precisely measure, report and verify emissions. In order to track progress and ambition, there is a global stock-take process with five-yearly reviews from 2018; the first of which is scheduled for 2023 (UNFCCC 2015a). To ensure sustained action, countries must progressively update their NDCs over time to strengthen the ambition and scope of their mitigation targets (UNFCCC 2015a).

As NDCs were developed through the course of negotiating the post-2020 climate change framework, they offer a new source of important information that was previously unavailable for analysis and comparison. The information communicated in an NDC provides an indication of a country’s level of ambition to address climate change, reflecting not only their willingness to combat climate change but also their domestic circumstances and capability. The targets expressed in NDCs also provide valuable information for understanding whether there are discrepancies between what is scientifically required to reduce emissions and what mitigation options countries adopt (Grassi et al. 2017).

The 187 'intended' NDCs (known as INDCs)[3] submitted prior to the negotiation of the Paris Agreement covered over 95% of global emissions (in 2010). While this represented an unprecedented effort from countries, scientific assessments of the impact of these pledges conclude they are insufficient to limit warming to well below 2°C (UNEP 2015; UNFCCC 2015b). Assessments of the aggregate impact of NDCs indicate an increase in the global

[2] The NDC for the European Union (and its 28 member states) is considered as one single NDC.
[3] INDCs were submitted prior to the negotiation of the 2015 negotiation of the Paris Agreement and become known as ‘NDCs’ when countries complete the formal ratification process to join the Agreement.

temperatures in the range of 2.6–3.1 °C by 2100 and leading to projected emissions of 55 gigatonnes in 2030 (UNFCCC 2015a; Rogelj et al. 2016). Enhancement and strengthening of mitigation targets, both in ambition and scope, is therefore required (Rogelj et al. 2016).

Meeting the goals of the Paris Agreement will involve significant long-term transformations of the global economy and will especially require substantial changes to the global energy system. Focus on the energy and industry sectors has meant emissions reductions from the land sector are often overlooked as a secondary mitigation option (Grassi 2017). This is largely due to the complex nature and high level of uncertainty associated with the land sector. Nevertheless, most countries have included in their NDCs targets and measures to reduce emissions from the LULUCF sector.

2.2. The land use, land-use change, and forestry (LULUCF) sector

Parties to the UNFCCC are required to record maintain, and update an inventory of their GHG emissions and removals as part of their obligations under the Convention. LULUCF is a greenhouse gas inventory sector that includes the emissions and removals of GHGs from direct human-induced land use, land-use change and forestry activities (IPCC 2000). LULUCF activities are recognized as a key mitigation strategy by either reducing GHG emissions (e.g. limiting deforestation), or removing GHGs from the atmosphere with the aim of stabilizing CO_2 concentrations (e.g. planting new forests or managing existing forests sustainably).

However understanding the impact of the LULUCF sector is complex and challenging. From a technical perspective, there are many unique challenges in the LULUCF sector, which distinguish it from other sectors. LULUCF is the only sector that includes both carbon emissions as well as carbon removals, operating as a sink (absorbing carbon) and a source (emitting GHG). In addition, natural disturbances (such as droughts, floods and wild fires), legacy effects (such as previous management decisions), non-permanence (where carbon stored in ecosystems may be released back into the atmosphere), high uncertainty compared to other sectors, and the difficulties distinguishing between anthropogenic and natural emissions and removals all contribute to the complexities of estimating, measuring and accounting for the LULUCF sector (Iversen et al. 2014; Hood and Soo 2017).

The LULUCF sector is also an inherently political and contentious issue. For many developed countries, (managed) land acts as a net sink, whereas LULUCF can represent a large source of emissions for many developing countries (especially for those with large areas of forest) due to on-going deforestation. Creating the methodologies to measure the

impact of LULUCF and incentivize land-based mitigation policies has been an extensive process. The inclusion of LULUCF into the Kyoto Protocol planted the roots for the on-going negotiations within the UNFCCC as a constant source of conflict between countries, due partly to the contested views about the fungibility (interchangeability) of LULUCF emissions and removals and fossil fuel emissions reductions (Dooley and Gupta 2016). Some countries were apprehensive about the inclusion of LULUCF into the Kyoto Protocol as could might allow countries to use largely LULUCF removals to meet their Kyoto targets and weaken their commitments to reduce GHG emissions from energy and industrial sources (Dooley and Gupta 2017; Fry 2002; Schlamadinger et al. 2007).

2.3. Definition of the land-use, land-use change, forestry (LULUCF) sector

A key discussion in the UNFCCC is how land and LULUCF is defined and used. The LULUCF sector is outlined by a complex set of definitions and accounting rules in Articles 3.3 and 3.4 of the Kyoto Protocol. However, different definitions and methodologies are used to estimate LULUCF emissions depending on whether it is used for national reporting or for independent scientific assessment purposes. Some of these differences include the definition of forest, coverage of areas and of carbon pools, and estimation methods used reporting agencies (Grassi et al. 2017). For example, the IPCC often uses definitions and methodologies in its periodic Assessment Reports that differ from those used for reporting under IPCC Guidelines for National GHG Inventories, resulting in different quantifications of emissions and removals from the LULUCF sector (Federici, Penman, and Wolosin 2016; Penman Michael Gytarsky et al. 2003).

2.4. Difference between LULUCF, AFLOLU and land use

Definitions of what constitutes ‘land use’ vary between different countries depending on how land is used and how it is reported. The definition of ‘forest land’, for example, may differ between countries, as Kyoto Protocol requires countries to define forests within specific boundaries; reporting under the UNFCCC does not (Iversen et al. 2014).

Many countries follow the six-land-use categories outlined by Intergovernmental Panel on Climate Change (IPCC) in the *Good Practice Guidance for Land Use, Land-use Change and Forestry* (GPG-LULUCF)[4] and *the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Agriculture, Forestry and Other Land Use* (Aalde et al. 2006):

- Forest land
- Cropland

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- Grassland
- Wetlands
- Settlements
- Other lands (e.g. bare soil, rock, ice, etc).

As well as the six land-use categories above, emissions and removals from living biomass; dead organic matter; and soil organic carbon are estimated. Emissions/removals from harvested wood products (HWP), such as the timber used in construction or in furniture, may also be reported as a LULUCF activity.

Another distinction is between the **LULUCF** sector and the Agriculture, Forestry and Other Land Use (the **AFOLU** sector), which is recognized by the Intergovernmental Panel on Climate Change (IPCC) in its scientific assessment reports. Although there is an overlap, AFOLU includes emissions from agricultural practices on farms, such as fertilizer application, rice cultivation and emissions related to livestock, whereas LULUCF does not (Iversen et al. 2014). The main difference between both groups is that the LULUCF includes carbon storage, emissions and removals, whereas there are only emissions in agriculture. This adds to the complexity of assessing NDCs as some countries have not distinguished between emissions and removals from LULUCF and from the AFOLU sector.

2.5. Literature on the LULUCF sector within NDCs

The literature on LULUCF and NDCs generally takes a technical focus. It aims to estimate the impact of LULUCF and its mitigation potential, including projecting the contribution of the LULUCF sector to the long-term temperature goal (Grassi and Dentener 2015; Grassi et al. 2017; Canadell and Raupach 2008; Federici, Lee, and Herold 2017; Roe, S., Streck, C., Weiner, P.H., Obersteiner, M., Frank et al. 2017). There is also a significant body of research on LULUCF emissions, removals and emission reduction accounting (Krug 2018; Briner and Konrad 2014; Iversen et al. 2014; Ellison, Lundblad, and Petersson 2011). These reports are used to inform countries with their reporting obligations and within the formal negotiations in the UNFCCC reporting and accounting discussions. While there is a large body of work on quantifying the mitigation impact of NDCs, the estimated impact of the LULUCF sector has been conservative or presented with strong caveats (Rogelj et al. 2017; Benveniste et al. 2018). A few recent studies have analyzed and quantified the role of LULUCF within countries mitigation commitments (Grassi 2017; Forsell et al. 2016; Federici, Lee, and Herold 2017).

Within the UNFCCC there is a distinction between reporting (estimating the emissions and removals of a country within a time period); and accounting (counting emissions and

removals towards national targets) which is required in order to track and assess progress towards achievement of mitigation targets. The IPCC provides guidance on how to estimate emissions and removals, while accounting decisions are made through the Kyoto Protocol and UNFCCC decisions. Unlike other sectors, LULUCF emissions are accounted for separately because of the different methodologies used to estimate and report for emissions and removals. Under the Kyoto Protocol, Annex I Parties must account for changes in carbon stocks from deforestation, reforestation and afforestation, and can choose to account for emissions from forest management, cropland management, grazing land management and revegetation.

The objective of literature on the LULUCF emissions and removals accounting is to improve or reduce the uncertainties in measuring and monitoring emissions and removals from sector. Unlike other sectors, different LULUCF accounting approaches (for example, accounting with net-net vs. gross-net approach; or use of baselines vs. reference levels) can in result in different estimates of emissions and removals from the land sector; therefore impacting a country's overall progress in achieving mitigation targets and picture of a countries level of ambition. Researchers have assessed the merits of different approaches by using case studies or interpreting the accounting rules. Their conclusions have mostly focused on whether accounting rules can incentivize countries to use effective measures to reduce GHG emissions through LULUCF activities, and how accounting rules could impact the scale of contribution from the LULUCF sector to the overall mitigation targets (Ellison, Lundblad, and Petersson 2011; Krug 2018; Schlamadinger et al. 2007; Höhne et al. 2007; Liu et al. 2011; Hood and Soo 2017).

Many scholars have also highlighted the political undertone beneath the LULUCF system. Despite the technical nature of LULUCF, it has been a source of political contention for many countries and the development of the sector and its rules has been subject to intensive negotiations (Lövbrand 2004; Dooley and Gupta 2017). The inclusion of the LULUCF sector into the Kyoto Protocol was contentious from the beginning, described as a *"…a negotiated solution produced by an evolving political process that had to deal with considerable scientific uncertainty*" (Schlamadinger et al. 2007). Countries such as Australia, Russia, New Zealand and Brazil have played an influential role in the development of rules and guidelines (Fry 2002; Schlamadinger et al. 2007).

Table 1 Key themes and messages from the literature

Key theme	Key messages	Key conflicts or divergences in literature

(1) The potential of LULUCF and the land sector in NDCs and the Paris Agreement	• Forests and the land sector have significant potential in climate mitigation. • As such, LULUCF is a core component of many countries' NDCs and is featured in the Paris Agreement.	• The extent to which LULUCF (and biological sinks) is used is questioned on the basis of scientific uncertainty. • Further research required on the trade-offs in land use mitigation policies.
(2) The uncertainties and complexities associated with estimating the impact of LULUCF	• The LULUCF sector has many unique features, which make it difficult to estimate its contribution in NDCs and complex to understand the overall impact of NDCs. • Different accounting approaches can show a different overall picture of a countries emissions profile and make it complex to measure, estimate and project the overall impact of the sector.	• Some consider the inclusion of the LULUCF sector and the subsequent development of the accounting rules as a political negotiation, dominated by countries with particular motivations • Better quality data and reporting requirements are needed to improve estimates to the LULUCF sector.

From assessing the relevant literature, there are two main messages that emerge relating to LULUCF and NDCs, which are examined below:

(1) The potential of forests and the land sector in NDCs and the Paris Agreement;

(2) Estimating the aggregate impact of LULUCF in NDCs and associated uncertainties.

2.6. Message 1: Forests and land-use in NDCs and the Paris Agreement have major potential

A large body of research is dedicated to highlighting the importance of the LULUCF sector (with a particular focus on forestry) in reducing GHG emissions or 'emissions gap'. Many studies have emphasized the viability of forestry and the land sector as a cost-effective option for climate mitigation (Busch and Engelmann 2017; Houghton, Byers, and Nassikas 2015; Kindermann et al. 2008; Griscom et al. 2017). Some scholars have made a case for the land sector to be a stronger mitigation option; stressing reasons such as the significant amount of carbon stored in forests, the 'self-correcting' nature of the sector (e.g. forest land that creates emissions from natural disturbances can recover and become forest sinks over time), and that the atmosphere does not differentiate against emission removals from fossil fuels or forests (Federici, Lee, and Herold 2017).

Houghton, Byers, and Nassikas found that strategic offsets from tropical forests could play a similar role to reducing emissions from fossil fuels by stabilizing and reducing atmospheric CO_2 concentrations, helping in the transition away from fossil fuels. In addition to providing mitigation opportunities, forestry has an important role in helping to maintaining climate stability, preserving biodiversity, providing access to ecosystem goods and services and

promoting sustainable development (Longva et al. 2017; Griscom et al. 2017; Smith et al. 2016). The co-benefits of maintaining forest also include improvements to health and safety, and enhancing food and energy security (Mullan 2014).

While some scholars have identified the competing demands and trade-offs associated with land-based mitigation, namely the risks to food productions and access to other ecosystem services, the land sector is acknowledged as an important additional opportunity for offsetting (Longva et al. 2017). The financial mitigation potential from forests is also recognized by the UNFCCC in its REDD+ (Reducing emissions from deforestation and forest degradation in developing countries) mechanism. REDD+ provides financial incentives to developing countries to reduce their emissions from deforestation and deforestation and to conserve and enhance forest carbon sinks.

However, research is divided about the extent in which LULUCF activities, and more generally land-based mitigation measures, should be used. While the idea of using the land sector as a way to offset fossil fuel use is commonly accepted within the scientific literature and the international climate regime, some argue that LULUCF emission reductions should not be considered on par with emission reductions from other sectors. Some scholars consider it "scientifically flawed" to use carbon sinks as way to offset CO_2 emissions from fossil fuels (Mackey et al. 2013, 552; Lövbrand 2004; Ajani et al. 2013). Lövbrand argues that the failure to consider the "effects of direct human activity in scientific projections of future terrestrial carbon storage has resulted in a simplified appreciation of the risks embedded in a global carbon sequestration scheme" (Lövbrand 2004, 449). Furthermore, scholars also caution over-reliance on engineered negative emissions technologies such as bio-energy with carbon capture and storage (BECCs) because of the associated land-use tradeoffs and ecological risks (Roe, S., Streck, C., Weiner, P.H., Obersteiner, M., Frank et al. 2017)

The criticisms surrounding the inclusion of biological sinks are related to the non-permanence of the sector and concerns about the environmental integrity of carbon accounting. As terrestrial carbon sinks can also function as sources of emissions and are reversible, some consider that they should not be comparable to emissions from fossil fuels. Initially, countries were concerned that including carbon sinks would function as a "loophole" for rich developing countries to evade historical responsibility and delay action to reduce GHG emissions from industrial sources (Bäckstrand and Lövbrand 2006; Lövbrand 2004). For example, countries may choose to promote certain accounting approaches that would make their emissions profile appear more favorable although some scholars however have provided evidence to rebuke these claims (Ellison, Lundblad, and Petersson 2011).

In response to the flaws and complexities within the LULUCF accounting system, many have called on ensuring the negotiations are based on "sound science" and highlight the importance of better quality data to understand the impact of various accounting approaches (Höhne et al. 2007). Climate advocacy groups have since promoted approaches where countries should "account for what the atmosphere sees" to prevent manipulation of the national GHG inventories and call for greater "scientific basis" to reduce such uncertainties (Climate Action Network Europe 2016). However, in reality creating an effective and equitable system for all countries is far more challenging, with one participant in the negotiations saying "*there is no perfect rule – what seems fair to one is an extra burden to another*" (Dooley and Gupta 2017, 492)

Nevertheless, the importance of LULUCF contributions in meeting the goals of the Paris Agreement has been increasingly recognized (Forsell et al. 2016; Grassi et al. 2017). Some reports have assessed LULUCF components of NDCs, but pay attention only to developing countries or provide a brief overview of targets. There are two comprehensive studies that assess, review and quantify the impact of LULUCF in the mitigation targets: Grassi et al conducted a comprehensive review of countries' (intended) NDCs and found that the land sector is expected to contribute to a quarter of pledged mitigation efforts up to 2030. Forsell et al also reviewed LULUCF targets[5] and found that while net LULUCF emissions will increase over time (on an aggregate global level), if all mitigation commitments (conditional and unconditional) were implemented net LULUCF emissions would significantly decrease[6], translating to as much as 20% of the full mitigation potential of all mitigation targets. Indonesia, Brazil, China and Ethiopia were identified as countries where significant LULUCF emission reductions were expected (Forsell et al. 2016). While both studies differ slightly on the anticipated impact of LULUCF sector, it is clear that the sector has significant potential, however also they emphasize the significant uncertainty and ambiguity associated with estimating LULUCF emissions and removals. In order to be consistent with an emission pathway that results in 1.5°C of warming, as per the Paris Agreement, emissions from the LULUCF sector need to be reduced. Kuramochi et al estimates that LULUCF emissions needs to be reduced to 95% below 2010 levels by 2030, and net deforestation should occur by 2025 as a benchmark for climate action required (Takeshi Kuramochi et al. 2018).

[5] Forsell et al reviewed INDCs, which were pledged prior to the negotiation of the Paris Agreement in 2015

[6] Reductions of 0.5 Gt CO_2 e year−1 (range: 0.2–0.8) by 2020 and 0.9 Gt CO_2 e year−1 (range: 0.5–1.3) by 2030, both compared to 2010 levels (Forsell et al. 2016)

2.7. Message 2: The uncertainties associated with estimating the impact of LULUCF

A key message reiterated throughout the literature is that the LULUCF sector is a source of great uncertainty, far more than other sectors, and hence is one of the most ambiguous aspects of global assessments of NDCs (Hof et al. 2017; Rogelj et al. 2017). The LULUCF sector is identified as a potential limitation by many reports and studies that attempt to measure and quantify the aggregate impact of NDCs. Models that assess the impact of NDCs have also underplayed the role of LULUCF due to the high level of uncertainties within the sector, particularly around how countries "estimate, project and account" for LULUCF emissions (Forsell et al. 2016, 1). Some of this ambiguity depends on a number of different assumptions, definitions and methodologies, such as the complexities of distinguishing between anthropogenic and natural causes of emissions (Boyd, Cranston Turner, and Ward 2015; UNEP 2015; UNFCCC 2015b; Rogelj et al. 2017). For example, Rogelj's analysis of the uncertainty associated with the estimated emissions of NDCs exclude LULUCF emissions (Rogelj et al. 2017). Many researchers have highlighted the importance of transparency and the need for further information and updated NDCs to reduce uncertainties of LULUCF projections and provide a clearer idea of the impact of the sector (Benveniste et al. 2018; Grassi et al. 2017; Rogelj et al. 2017).

The UNFCCC synthesis report identified the LULUCF sector as a source of uncertainty in its earlier assessments of INDCs (UNFCCC, 2015b). The approaches used for estimating, projecting, and accounting emissions and removals differ between various countries, with some NDCs expected to use specific accounting rules, whiles other taking a full carbon accounting approach (i.e. include LULUCF net emissions and removals like any other sector). The report concluded that providing a quantitative evaluation of the aggregate effect of the INDCs would be challenging due to the lack of clarity and "*comprehensive information on the assumptions and methods applied in relation to LULUCF*" (UNFCCC, 2015b).

For these reasons, some assessments of NDCs (in both fairness and cost) do not include emissions reductions from LULUCF (Hof et al. 2017). For example, the Climate Action Tracker (CAT) rates individual country's NDCs based on effort-sharing principles and the range of emission levels NDCs should aim for to be consistent with pathways to achieve the temperature goal (Climate Action Tracker 2018). LULUCF is excluded from emission allowances in CAT's fairness assessments due to the large uncertainties in the sector and the need to prioritize decarbonisation of the energy system, as emission reductions from LULUCF will not replace the need the make substantial changes to reduce emissions from energy and industrial sectors. The inclusion of LULUCF emissions and reductions may

potentially disguise trends, such as increasing emissions from the energy and industrial sectors.

As achieving the 2 or 1.5°C temperature goal requires decarbonisation and deep long-lasting transformations in the global energy system, most assessments focus on emissions reductions from energy and carbon-intensive industries. The LULUCF sector has vastly different economic drivers and long-term dynamics that those for the energy and industrial sectors. Although mitigation activities from energy, industrial processes, solvent and other product use, agriculture and waste sectors are critical and should not be understated, current assessments leave a substantial gap by not comprehensively considering the mitigation role of the LULUCF sector. While there is a clear need to consider of the LULUCF sector within NDC assessments, its inclusion relies on accurate scientific data and clear reporting (Grassi et al. 2017). In order to compare NDCs, the LULUCF sector (including its associated uncertainness and fluctuations and effect of accounting rules) should be separated from all other sources of emissions. Therefore, further understanding of the sector and disentanglement of the uncertainties is needed.

There are a growing number of reports that specifically addressed the LULUCF pledges in NDCs (GIZ 2017; Schletz et al. 2017; Amponin and Evans 2016; Lee and Sanz 2017), which summarize the different approaches taken by countries in how they included the LULUCF sector. These reports highlight the difficulties in calculating the specific measurable emissions reductions from the sector due to lack of data or capacity to collect information (GIZ 2017). Many reports stress that the lack of clarity and consistency within NDCs to account for the LULUCF sector is a source a significant uncertainty in the potential mitigation impact of NDCs, specifically citing the lack of description for the methods of assumptions used in the LULUCF sector reporting or accounting, or a lack of information. There have been some attempts to quantify the impact of LULUCF within NDCs, which emphasis the potential of sector but also the underlying uncertainty associated with estimates (Grassi et al. 2017). While these reports provide a useful snapshot overview of the approaches used by countries to include the LULUCF sector, they do not go beyond this analysis and do not attempt to provide insights into how or why variations in coverage exist (Altamirano et al. 2016).

2.8. Research Gap

The literature for mitigation scenarios to reach the goal Paris Agreement (Robiou du Pont et al., 2016; Rogelji et al., 2016) or suggested pathways for decarbonization (Rockström et al., 2017), focus predominately on the energy sector. Assessments of the LULUCF sector tend

to be conservative due to the significant uncertainties and challenges in estimating the influence of the sector. Consequently, there is a small but growing body of research to understand the contribution LULUCF in NDCs. Studies have attempted to quantify the impact of LULUCF in NDCs or suggested pathways for use of land-use policies in the future; highlighting the importance of the sector in reaching mitigation targets (Forsell et al. 2016; Grassi et al. 2017; Roe, S., Streck, C., Weiner, P.H., Obersteiner, M., Frank et al. 2017; Federici, Penman, and Wolosin 2016). While these assessments provide a useful overview of the approaches used by countries to include the LULUCF sector, they do not go beyond this analysis and do not attempt to explain how or why variations in LULUCF coverage exist or how this may be linked to countries national circumstances and capabilities.

NDCs “represent our best understanding of the climate actions countries intend to pursue after 2020" (Rogelj et al. 2017). They provide a new source of information to assess the ambition of countries mitigation priorities, reflecting their national circumstances and capacity. As yet, there have not been any attempts to examine the national circumstances and factors underlying specific components of NDCs. It is necessary to understand national policy priorities in order to gain a greater understanding of countries’ national ambitions. While understanding the factors that influence countries behaviour on climate policy is a wide-ranging goal, such an assessment may provide additional insight into the overall impact of NDCs and feasibility of countries proposed actions.

In addition, there are many ways to assess the ambition of NDCs and have been several substantial attempts to track post-2020 climate action. Höhne et al summarized existing literature to identify eight distinct assessment approaches that either i) relate to mainly to moral obligations, relating to the principle of common but differentiated responsibilities and respective capabilities, (such as change in recent trends or effort sharing); or to ii) technical necessity/efficiency, that is whether an NDC is in line with what is technically required for a global target, regardless of moral obligation or previous action, (such as decarbonisation indicators or globally cost-effective scenarios) (Höhne et al. 2018; Röser et al. 2015; Höhne, N.; Ellermann, C.; Fekete 2014; Aldy, Pizer, and Akimoto 2017). Although these assessments address the impact of NDCs relating to the goals of the Paris Agreement or fair share effort relating to the historical responsibility of countries, they do not consider the national circumstances or capabilities of countries.

Furthermore, the impact of non-energy policies, such as on forestry, on energy systems has been identified a knowledge gap (Cox, Royston, and Selby 2016). Cox (2016) highlights the lack of research on the impact of non-energy policy on energy systems is a gap in the energy

governance literature and “makes the energy effects of non-energy policy invisible and hard to challenge” (Cox, Royston, and Selby 2016, 5).

2.9. Conclusion

From this review, it is clear that the LULUCF sector presents many opportunities, but also significant challenges and uncertainties. Research on LULUCF in NDCs has focused on understanding and estimating the impact of LULUCF activities, especially the role of forests, in climate mitigation. However, there is little assessment of broader context relating to countries national circumstances for how LULUCF activities are used in climate mitigation. The concerns on the extent that LULUCF and more widely, land-based mitigation, should be used are based on technical scientific arguments (e.g. the uncertainty and the biophysical limits on the land and atmosphere) or political arguments (e.g. allowing offsets from LULUCF as a way to put off reductions in more expensive sectors, such as energy). While literature on the development of the LULUCF sector within the UNFCCC alludes to a complex and convoluted process dominated by countries’ national interests (Fry 2002), there has been little to no consideration in the new context of NDCs and the Paris Agreement. Attempts to quantify the impact of LULUCF emissions, and therefore understand the long-term impacts of NDCs and their uncertainties, do not include assessments of the national circumstances and capabilities for how the LULUCF sector is treated. In order to understand the feasibility of mitigation targets, attention should be paid to the national circumstances that drive a country to include or exclude LULUCF in its pledges.

3. Analytical framework and methodology

This chapter identifies relevant theories that may explain how and why countries include the LULUCF sector, and then introduces the analytical framework and methodology that will be used in this research.

3.1. Relevant theories and perspectives

There are many theories from various disciplines that help to understand the relationship between the national circumstances and capabilities of countries and their climate change actions, I will focus on theories that relate to land-use and global comparative environmental politics.

Forest transitions and land-use theory

A relevant theory in understanding the link between land use and countries LULUCF pledges is that of forestry transitions. The term forest transition was first introduced to describe the pattern in which forested land changes as societies undergo industrialization and urbanization, based on historical case studies in North America and Europe (Mather 1992). The theory proposes that forested areas which initially experience deforestation eventually reach a turning point where they begin to deforest, portrayed by a U-shaped curve over forest cover and time (Barbier, Burgess, and Grainger 2010). The concept is relevant in understanding how and why countries with large areas of forestry undergo long-term changes from net deforestation to net reforestation or a partial recovery of forest cover. Figure 1 shows the phases of a forest transition over time.

The theory of forest transition provides a useful way to characterize the changing relationship between forests and societies and may help to explain how land use transitions over time are linked to countries' national circumstance and capability, that are the broader societal, political and economic changes (Rudel, Schneider, and Uriarte 2010). There has been substantial progress on expanding the forest transition literature and multiple theories to explain what occurs before and after forest transitions (Rudel et al. 2005). However, the literature diverges on the assortment of drivers and dynamics that lead to forest transitions (Meyfroidt and Lambin 2011; Kull 2017; Rudel et al. 2005; P. Meyfroidt, Rudel, and Lambin 2010; Wilson et al. 2017; Schwartz et al. 2017).

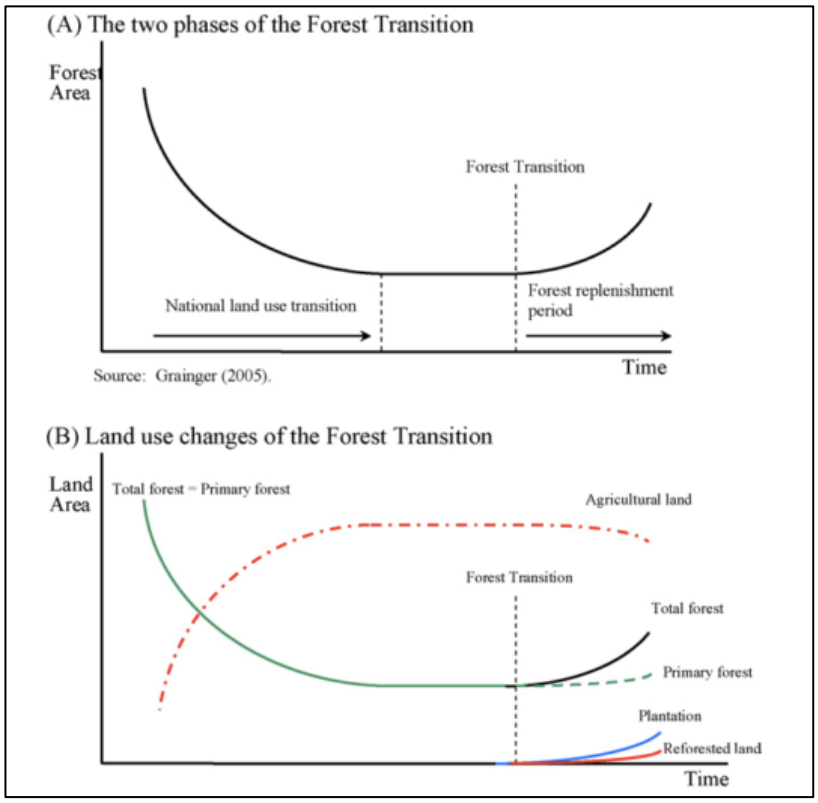


Figure 1 Land use change and the forest transition curve: (A) the two phases of the forest transition; (B) land use changes of the forest transition. Source: (Barbier, Burgess, and Grainger 2010)

Pathways to forestry transitions vary regionally and can include factors from economic development, demographic characteristics, and geographic features. According to literature, there are two main pathways for what occurs after/during the forest recovery stage. The first is an economic development path, where after agricultural expansion, farm workers leave the land for non-farm related employment, resulting in the abandonment of land, eventually reverting to forest. The shift of farm labour due to urbanization and economic development underpins many modernization theories (Lambin and Meyfroidt 2010). The second pathway relates to the loss of forest creating the opposite impact – the continued declines in forest cover results in the increasing cost of forest products, leading to land-owners to convert land into more cost-effective use for forest plantations, instead or crops or pasture grasses. This is referred to as the forest scarcity path (Rudel et al. 2005).

Furthermore, different factors drive forest decline as opposed to forest recovery. Although there is no unified theory on forest cover change, for most countries the decline in forest cover is predominantly due to the conversion of primary forest to agricultural land uses (Rudel et al. 2005). Correspondingly, the two main causes of the growth of total forest area are changes in land use, such as the conversion of agricultural land into forest, and the

establishment of timber plantations (Barbier, Burgess, and Grainger 2010). Scholars have since looked to tropical countries or from a global perspective to apply the theory.

For the purposes of this research, the forest transition theory provides one perspective to understanding the national circumstances that may guide countries' to use LULUCF measures. The hypothesis here is that countries treat LULUCF targets within their NDCs in accordance with their stage in forest transitions. Countries which are expected to benefit from forest transitions (in terms of emissions reduction) would be more likely to set up clear and ambitious LULUCF targets than countries for which forest transitions are less relevant.

Global environmental politics

A supplementary approach is to draw on theories used in global environmental politics to understand what factors influence the behavior of states' in climate policy (Bernauer 2013). There have been several quantitative studies which assess how economic factors influence emissions activity, looking at the institutional conditions (Lachapelle and Paterson 2013), the credibility of policy commitments (Bernauer and Gampfer 2015), and political regime and conditions (Cao et al. 2014; Purdon 2015). Factors which influence the frequency of mitigation policies in countries include economic development (higher GDP per capita countries have more climate policies) and the availability of natural resources (more fossil fuel reserves correlate with fewer climate policies) (Höhne et al. 2015). Although literature and economic modelling efforts recognise that climate mitigation options vary between countries depending on their national socio-economic objectives, energy resource endowment and climate policy ambition (Fragkos et al. 2018), there has been little analysis on examining the national circumstances and capabilities that influence countries to include land-based mitigation policies in NDCs.

One study has attempted to assess why countries choose to use carbon sequestration-based mitigation options (Røttereng 2018). Røttereng compared the support for carbon capture and storage (CSS) and the REDD+ scheme between twenty-six countries using perspectives from public policy, political economy, and international relation. The study infers that an important consideration of why countries endorse carbon sinks is to be recognized as responsibly participating in global climate politics, without abandoning fundamental energy interests. By supporting CSS and REDD+, countries are able to signal their "normative support for mitigation measures that have significant potential, without harming their economic interests" (Røttereng 2018, 70). This suggests that even if countries do not pledge ambitious and comprehensive economy-wide targets, countries acknowledge the importance

of signaling commitment to climate change using “sinks as symbols”. The findings by Røttereng provide some useful insights; although my research will not assess how countries have included LULUCF sector compared to other land-based mitigation policies, it will assess and compare how countries have included LULUCF commitments in NDCs.

Under this approach and supporting the forest transition theory, the supplementary hypothesis is that countries treat LULUCF targets within their NDCs in accordance with their national economic structures. Countries with high levels of GDP are more likely to include LULUCF measures. This may represent a way to signal their commitment to climate action and ambition, without impairing their economic interests, or because of the mitigation potential of the LULUCF sector as it represents a net sink.

3.2. Analytical framework

Although there are several dynamic factors that may explain why a country uses the LULUCF sector for climate mitigation, both these theories provide a useful platform for starting point for research. In order to understand how a countries national circumstances and capability determine the treatment of LULUCF in NDCs; I use insights from forest transition literature and environmental political science. I will use the following analytical framework to understand the factors that determine the treatment of LULUCF in NDCs.

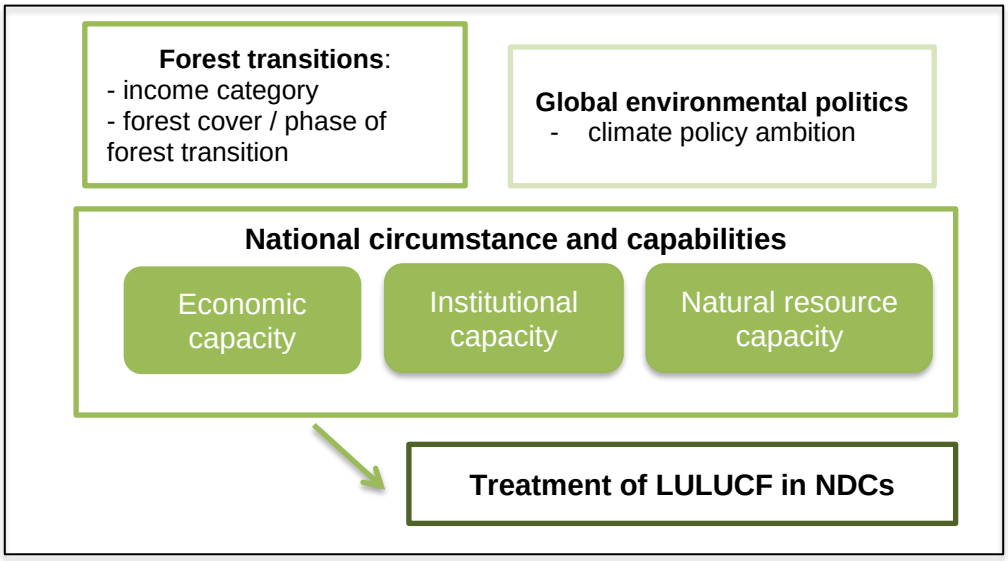


Figure 2 Analytical framework: theories and national circumstances

I aim to understand whether the treatment of LULUCF is related to socio-economic factors and national circumstances and capabilities. From this analytical framework, we can expect treatment of LULUCF in NDCs will depend on the national profiles and priorities of a country,

such as its forestry profile (e.g. size of forest cover and whether it is evident that the country is undergoing a forest transition), and emissions profile (e.g. contribution to global GHG and the extent to which a country needs to use biological sinks). My research addresses a small subset of broader, generalised questions about what drives climate change policy at the national level - including the overall level of action on climate change, and the type of policy implemented (Lachapelle and Paterson 2013).

From grouping NDCs according to how countries treat LULUCF sector, I am able to draw conclusions that relate to the following objectives and questions:

Table 2 LULUCF objectives and questions framework

Research objectives	Research question(s)
1. Categorize NDCs based on their LULUCF component	How do countries exclude or include the LULUCF sector? What approaches are used?
2. Identify the national circumstances and drivers of national mitigation policy related to the LULUCF sector	Why do countries choose to include or exclude LULUCF measures in their NDCs? Examine the relationship between how and why countries have included the LULUCF sector between factors such as: - emissions trend - forest cover - income category

3.3. Methodology

Part one: Assessing NDCs

I assess NDCs communicated by Parties as part of their formal ratification process to the Paris Agreement. As of June 2018, 176 Parties have ratified the Paris Agreement and 170 Parties have submitted their first NDCs. In order to capture significant forestry countries such as the Russian Federation, INDCs from countries who have not yet formally joined the Paris Agreement are also included in analysis. In total, 166 NDCs[7] (including 24 INDCs) were analysed in this research.

All available NDCs are categorized based on how the LULUCF sector is treated. The three categories to divide the variety of approaches in NDCs is depicted in the diagram below, updated and adapted from Forsell et. al (2016)

[7] The NDC from the EU and its 28 Member States is counted as a singular NDC.

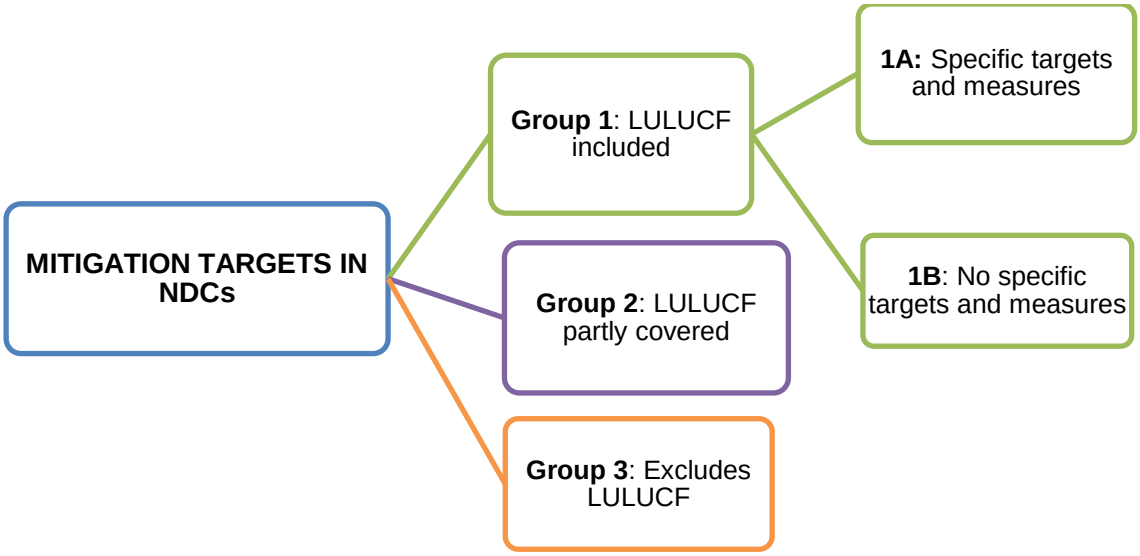


Figure 3 Grouping NDCs, adapted from Forsell et al 2016

The table below outlines how I have defined each grouping.

Table 3 Definition of LULUCF groups

Group	Definition / justification for grouping
Group 1A	NDCs that explicitly include LULUCF in mitigation targets. These NDCs provide specific quantifiable information on the policies, measures or targets for addressing LULUCF emissions and removals.
Group 1B	NDCs that include the LULUCF sector in mitigation targets but not specify any quantifiable information, such as policies and measures or targets for addressing LULUCF emissions and removals.
Group 2	NDCs that partly include the LULUCF sector: NDCs that exclude LULUCF from the mitigation target but include separate policies, measures or specific targets for reducing LULUCF emissions.
Group 3	NDCs that explicitly exclude LULUCF from mitigation targets and do not include any measures or polices for the LULUCF sector.

I will look at aspects of the mitigation target as they relate to the LULUCF sector. The main method in this research is documentary analysis of all available NDCs. In particular, I will look at the:

- **Type of mitigation target**: Mitigation targets can be expressed in terms of a GHG reduction, mix of GHG and non-GHG, or just actions; and can be set relative to an absolute base year or to a BAU scenario. Although targets are nationally determined, the Paris Agreement states that developed countries should set economy-wide, absolute emission reduction targets and developing countries are encouraged to take economy-wide targets over time (Hood and Soo 2017).
- **Accounting approaches:** as identified in the literature, the type of accounting approach can result in different estimates of emissions and removals from the

LULUCF sector, and can affect the headline number and perceived ambition of countries' mitigation efforts. The dichotomy between different accounting approaches relate to:

  - Estimating human-induced net emissions and removals: this can either be land-based (which is used in national GHG inventory reporting under the Convention) or activity-based (used for reporting LULUCF activities under the Kyoto Protocol, however there are issues of comparability because reporting of some activities is voluntary).
  - Identifying the baseline for accounting: this can be either net-net, which compares the net emissions (emissions minus removals) in the target year against net emissions in the base year; or gross-net, where estimates of net emissions in the target year are not referenced to a base year (Hood and Soo 2017).

- **Conditionality of target:** Countries may include conditions on targets so the implementation of action is based on the provision of and access to finance and support. For many developing countries, barriers to achieving NDCs include their level of capacity (financial, institutional and technological).

Part two: Assessing national circumstances and capabilities

Grassi et al. (2017) and Forsell et. al (2016) have conducted an extensive assessment of the LULUCF components in NDCs, which form a foundation for my research. However, I will go beyond this analysis by using different perspectives to examine the particular national circumstances of how countries have treated the LULUCF sector. I use both NDCs and additional evidence to link the treatment of LULUCF in selection countries' NDCs to their national circumstances. In order to consider the LULUCF commitments in NDCs, I will assess on the forestry sector (forest area and cover) and the emissions profiles (GHG and LULUCF emissions) in all groups. The institutional arrangements and political context of a country will not be considered in the scope of this research because of resource constraints.

I use UNFCCC classifications of income, which are based on the OECD Annex typology. Annex I are industrialised and high-income countries, Non-Annex I countries are economies-in-transition, and non-Annex I members are the remaining Parties to the UNFCCC, which are the developing countries.

To assess the national circumstances of a country, I will use official documents submitted by countries' as part of their reporting obligations under the UNFCCC to support the analysis of NDCs. I will use countries' latest National Communication submissions as well as Biennial

Reports (from Annex I countries) and Biennial Update Reports (from non-Annex I / developing countries) as additional evidence. According to reporting guidance, countries shall "*tak[e] into account their national circumstances*" in the preparation of biennial reports (Decision 2/CP.17 in UNFCCC 2012). National communications include information on a countries' national GHG inventory, mitigation actions, and the constraints and gaps related to capacity needs, and provide insight into how countries have self-described their national circumstances.

3.4. Data sources and interpretation

The main source of data are countries NDCs, which were taken from the official public UNFCCC interim registry. All remaining INDCs were taken from the UNFCCC official submission portal. NDCs were assessed for their mitigation target and treatment of the LULUCF sector. All other data was collected by analysing documents, scientific articles, and using databases, as depicted in Table 4 below.

Table 4 Sources of data and methods

Data classification	Source	Method/ Notes
Global GHG emissions (with and without LULUCF): This includes emissions from: the energy, industrial processes, agriculture and waste sectors.	WRI CAIT Climate Data Explorer.	GHG instead of CO_2 was measured as LULUCF emissions also include other GHG such as methane and nitrous oxide GHG emissions for each country was added together, depending on their relevant LULUCF grouping. % of global emissions was calculated by summing country GHG contributions for each category.
CO2 emissions per capita	World Bank, 2015	Annual data on 'CO2 emissions per capita' by country is published by the World Bank
Land-Use Change and Forestry emissions ($MtCO_2$)	WRI CAIT Climate Data Explorer, 2015[8] FAO STAT, 2015 World Bank, 2015	LULUCF emissions were taken from the WRI CAIT Climate Data tool. Data for LULUCF emissions (based on IPCC category) were taken from FAO STAT. % of global LUCF emissions was calculated by summing each country GHG contribution for each category.
Forest area (sq km)	World Bank, 2015	Annual data on 'Forest area (sq. km)' by country is by the World Bank
Forest area (% of land)	World Bank, 2015	Annual data on 'Forest area (% of land area)' by country is published by the

[8] WRI was granted a non-exclusive, non-transferrable right to publish these data by the FAO for Land-Use Change and Forestry data in the Country GHG Emissions.

		World Bank
Land area (sq km)	World Bank, 2015	Annual data on land area sq km)' by country is published by the World Bank
Forest cover	Global Forest Watch, 2018	Data on forest cover should be used for further analysis
Forest change	Global Forest Watch, 2018	Data on forest cover should be used for further analysis
Deforestation / reforestation %	Global Forest Watch, 2018 MongaBay, 2018	Data on reforestation should be used for further analysis
Global tree cover gain	Global Forest Watch, 2018	Data on global tree cover gain should be used for further analysis
GDP per capita	World Bank, 2015	Annual data on 'GDP per capita' by country is published by the World Bank
Population growth	World Bank, 2015	Annual data on population growth by country is published by the World Bank

3.5. Scope of research

For the purposes of my research, I will focus LULUCF as it relates to climate mitigation targets within NDCs. I assess all available NDCs and INDCs submitted by all countries in the world by March 2018

While LULUCF is an important feature of adaptation commitments, these elements are not considered within scope of my research. This is because my research focuses on the long-term temperature and mitigation goals within the Paris Agreement and the broader consideration of land-use within climate mitigation priorities. I will focus on carbon-related terrestrial emissions, i.e carbon dioxide emissions and removals from forests, soil carbon, and cropping and grazing activities. This definition is consistent with the reporting guidelines on LULUCF activities under the IPCC. I will not consider dominant sources of emissions from the agricultural sector, such as non-CO2 agricultural activities (such as livestock management and fertilizer use).

3.6. Limitations

Limitations to scope

This research is limited in its scope as it only looks at the LULUCF policies and preferences as outlined in NDCs as of May 2018. I have specifically assessed how countries have included the LULUCF sector as a proxy for how biological sinks are used, based on the assumption that countries will use LULUCF activities at the same rate as other land-based mitigation policies. However, LULUCF is only one part of land use mitigation policies. Furthermore, the term LULUCF is defined in a particular way to reflect how countries report

and measure emissions. To comprehensively consider how countries use the land sector and forests, this research could be expanded more broadly to include land-based mitigation policies such as the REDD+ programme or negative emissions (non-biological sinks).

Secondly, the role of negative emissions technology such as bioenergy with carbon capture and storage (BECCS) is not included in my research. There is an ongoing body of research on the future of negative emissions in the Paris Agreement. Many projected pathways consistent with the goals of the Agreement incorporate emission's reductions from BECCs, highlighting their significant mitigation potential. While there are also significant associated risks and high costs associated with BECCS, this research that warrant their own analysis.

Limitations to the analytical framework and theory

Assessing and measuring forest transitions requires long-term changes in the extent of forests. Finding the relevant data to comprehensively understand forest transitions is a significant limitation. Using case studies of significant countries as an example of high/low ambition and high/low LULUCF commitments could be an additional step to this methodology. However because of time, I only assess NDCs as an aggregate and make my findings based on generalisations within each grouping. From my analysis, I have identified several countries that warrant further analysis as case studies – such as Russia and the Democratic Republic of Congo.

In addition, the political regime and institutional capacity of a country's national circumstances and capabilities was not included in this analysis. If this work were expanded, this would be likely next step. This could include using GDP per capita, data on the size of the economy, and the POLITY IV regime index as data.

Limitations to methodology

I assess NDCs on their face value, rather than using Integrated Assessment Models or testing relationships using bivariate statistics and multivariate regressions. This type of statistical analysis was not used in this research due to time and resource constraints. However, the data I have created would be relevant for testing relationships using statistical analysis. Such analysis would strengthen the generalizations and results of this research and make it more scientifically rigorous and statistically significant. Methodologies used by Lachapelle and Paterson or Røttereng are examples of possible multi-variable analyses, which could be used to evaluate the linkages between climate policies and national circumstances. Cluster analysis of LULUCF groupings would also make this research more coherent. If this work was to be expanded further, this would be a likely next step.

Secondly, I also include and treat INDCs as equal to NDCs in order to include significant forestry countries such the Russian Federation, Suriname and Tanzania. Practically, INDCs are not equivalent to NDCs as Parties are not officially part of the Paris Agreement, and thereby not yet bound to the same obligations and mitigation targets. An analysis of the LULUCF coverage for INDCs would generate useful insights into the current level of action and ambition by countries and give an indication of the gap between emissions covered by the Paris Agreement.

The methodology used in this research (classifying NDCs and then examining the relative national circumstances of each group) could be replicated and used to assess other sectors in countries NDCs. The most significant sector for analysis is the energy sector. As the greatest source of emissions, assessing the energy (or industrial sectors) could provide valuable insights into how countries have prioritized their national climate policies and how feasible it is to achieve their own mitigation targets in relation to country's energy profiles.

Evaluating NDCs is a relatively new field and countries are still grappling with the many possible ways to assess the actions and ambition of mitigation targets. Assessing the LULUCF components of NDCs is not meant to be a substitution for gauging a countries ambition. Rather it helps to provide supplementary information to understand the ambitions, priorities and capacities of countries. This is especially relevant for low-income countries that currently rely on forests and LULUCF as a net sink for GHG emissions, but is expecting greater emissions from the LULUCF sector in the future or greater emissions from the energy and industrial sector.

4. Results

This chapter presents the results of the analysis in two parts. Firstly, I will provide general results of the categorisation, focusing on aspects related to the type of NDC and then analysis of specific LULUCF groups. Secondly, I test the hypothesis by looking at the national circumstances and capabilities of countries within the categories.

4.1. General overview of NDCs

Overall 126 out of 166 NDCS included or referenced the LULUCF sector in their mitigation targets or actions. The sector was explicitly included in 63% of mitigation targets (104 NDCs) and explicitly excluded in 25% of targets (40 NDCs). Table 5 and Figure 4 provide an overview of the number of NDCs grouped according to their treatment of LULUCF emissions. Table 7 provides the list of countries in each group.

Table 5 Number of NDCs in LULUCF categories. Source: Own analysis

Group categories	Number of NDCs
1. NDCs that include LULUCF	104
1a. With explicit targets and measures	(42)
1b. No listed targets and measures	(62)
2. NDCs that partly include LULUCF	22
3. NDCs that do not include LULUCF.	40
Total	166

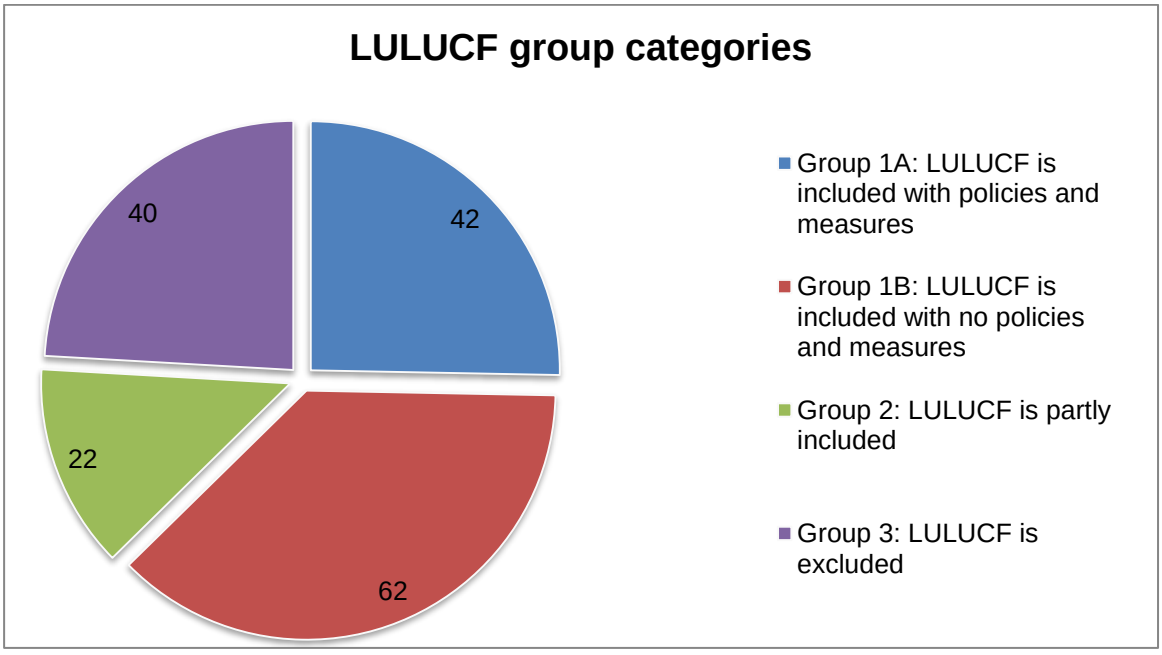


Figure 4 Overview of LULUCF categories. Source: Own analysis

As indicated by the UNFCCC Secretariat in the pre-assessment of INDCs, there are considerable variations in how countries have discussed the LULUCF sector. Some NDCs

included specific information on the approaches and methodologies to estimate and account for emissions and removals, whereas others did not provide any information, or in inconsistent metrics (e.g. some policies were measured in terms of hectares of forest gained whereas others provided estimates of emissions reductions in $C0_2e$). Many countries cited the difficulties in estimating the specific emission reductions for LULUCF are due to a lack of data and capacity to collect information. The lack of clarity and consistency provided creates a significant degree of uncertainty and ambiguity in understanding and comparing the mitigation impact of all NDCs.

4.2. Geographic coverage

The NDCs that included and partly included LULUCF spanned a wide geographic area, with the majority of coverage from the African continent followed by Asia and Latin America and the Caribbean. The geographic area breakdown of NDCs is included in Table 6 below.

Table 6 Geographical coverage for NDCs that included LULUCF. Source: Own analysis

Area	Number of NDCs that include/partially include LULUCF	% of NDCs that include/partially include LULUCF	Total Number of NDCS
Africa	48	28.9	56
Asia	25	15.1	28[9]
Latin America and the Caribbean	25	15.1	31
Europe (including EU28)	10	6.0	19
Oceania	8	4.8	18
Middle East	4	2.4	12
North America	2	1.2	2
Total	126	73.5	166

[9] Including Armenia, Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan

Table 7 List of NDCs and INDC according to groups

GROUP 1: LULUCF is covered		**GROUP 2: LULUCF is partly covered**	**GROUP 3: LULUCF is not covered / excluded**
1a: Measures and/or specific targets are explicit	**1b:** No measures and/or specific targets are listed		
Algeria; Angola [*INDC*]; Azerbaijan; Belize; Benin; Bolivia; Brazil; Burundi; Cabo Verde; Cambodia; Central African Republic; Chad; China; Colombia [*INDC*]; Comoros; Democratic Republic of the Congo; Eritrea [*INDC*]; Ethiopia; Gabon; Ghana; Guyana; Haiti; India; Indonesia; Japan; Lao People's Democratic Republic; Madagascar; Malawi; Mali; Morocco; Namibia; Nepal; Norway; Panama; Republic of Congo; Senegal [*INDC*]; South Africa; State of Palestine; Sudan; Uganda; Uruguay; Zambia	Afghanistan; Antigua and Barbuda; Argentina; Armenia; Australia; Bahamas; Bhutan; Bosnia and Herzegovina; Brunei [*INDC*]; Burkina Faso; Canada; Costa Rica; Dominica; Dominican Republic; Equatorial Guinea [*INDC*]; Grenada; Guatemala; Iceland; Jordan; Kazakhstan; Kenya; Kyrgyzstan[*INDC*]; Liechtenstein; Malaysia; Mauritania; Mauritius; Mexico; Mozambique [*INDC*]; Myanmar [Burma]; New Zealand; Niger; Nigeria; Democratic People's Republic of Korea (North Korea); Pakistan; Paraguay; Peru; Philippines [*INDC*]; Republic of Moldova; Russia [*INDC*]; Rwanda; Saint Vincent and the Grenadines; San Marino [*INDC*]; São Tomé and Príncipe; Serbia; Sierra Leone; Singapore; Solomon Islands; Somalia; South Sudan; Sri Lanka; Suriname [*INDC*]; Switzerland; Tajikistan; Tanzania [*INDC*]; Togo; Tunisia [*INDC*]; Turkey; Ukraine; United States; Vanuatu; Venezuela; Viet nam	Bangladesh; Cameroon; Chile; Côte d'Ivoire; Djibouti; Ecuador [*INDC*]; El Salvador; EU28 Member States; Gambia; Georgia; Guinea; Guinea-Bissau [*INDC*]; Honduras; Lebanon [*INDC*]; Lesotho; Mongolia; Papua New Guinea; Samoa; Timor-Leste; Thailand; Tonga; Zimbabwe	Albania; Andorra; Bahrain; Barbados; Belarus; Botswana; Cook Islands; Cuba; Egypt Fiji; Iran [*INDC*]; Iraq [*INDC*]; Israel; Jamaica; Kiribati, Kuwait [*INDC*]; Liberia [*INDC*] Macedonia (Republic of); Maldives; Marshall Islands; Micronesia; Monaco; Montenegro; Nauru; Niue; Oman [*INDC*]; Palau; Qatar; Saint Kitts and Nevis; Saint Lucia; Saudi Arabia; Seychelles; Republic of Korea (South Korea); Swaziland; Trinidad and Tobago; Turkmenistan; Tuvalu; United Arab Emirates; Uzbekistan and Yemen [INDC].
TOTAL: 42 NDCs	**TOTAL:** 62 NDCs	**TOTAL:** 22 NDCs	**TOTAL:** 40 NDCs

4.3. Coverage of global GHG emissions

In terms of global emissions coverage, the countries that included or partially included the LULUCF sector represent over 97% of global net emissions in 2012. In 2012, the NDCs that included the LULUCF sector contribute about 70% of the total GHG emissions (including emissions from land-use change and forestry). The group of NDCs that did not include LULUCF emissions (24% of NDCs surveyed) contributes about 7.8% of global emissions. From this group, the most significant global emitters that did not include LULUCF in their NDC are Iran, South Korea, Saudi Arabia, Egypt and Iran. These countries are explored on page 57 below.

Table 8 GHG emissions per grouping. Source: CAIT Climate Data Explorer. 2015. Washington, DC: World Resources Institute. Available online at: http://cait.wri.org

Grouping	**Number of NDCs**	**Total GHG Emissions Excluding** LUCF **($MtCO_2e$)**	**Total GHG Emissions Including** LUCF **($MtCO_2e$)**	**% of global emissions (including** LUCF**)**
Group 1	104			70,6%
Subgroup 1a	(42)	16 406,02	17 667,83	37,1 %
Subgroup 1b	(63)	14 836,96	15 966,58	33,5 %
Group 2	21	1 202,13	1 663,07	3,5 %
Group 3	40	89 79,54	10 333,62	21,7 %
Total	166	1644,65	2674,1	1,664

4.4. Coverage of global forest cover

In terms of global forest cover, the countries that included or partially included the LULUCF sector represent 90% of global forest cover.

Table 9 Coverage of global forest cover. Source: World Bank, 2015

Grouping	**Number of NDCs**	**% of global forest land**	**Total** LUCF emissions **($MtCO_2e$)**
Group 1	104	90	
Subgroup 1a	(42)	(37%)	2172,53
Subgroup 1b	(63)	(53%)	453,70
Group 2	21	8%	136,62
Group 3	40	1%	-49,51
Total	166	99%	2713,34

Countries with the largest forest area all included LULUCF into their NDCs, however to varying degrees of information and coverage. The table below shows the coverage of the top ten significant forestry countries (in terms of forest area) and their relative LULUCF grouping.

4.5. Income category coverage

Most Annex I countries included the LULUCF sector in NDCs – the exceptions were South Korea who indicated that the decision to include the sector would be made later, and Israel. Most Annex I countries were categorised in Group 1B, as they included LULUCF but did not provide policy measures or specific targets. Non-Annex I countries were more evenly spread.

Table 10 Income coverage for NDCs that included LULUCF. Source: Own analysis

	Number of NDCs that include/partially include LULUCF	% of NDCs that include/partially include LULUCF	Total Number of NDCS
Annex I	11[10]	85%	13
Non-Annex I	111	72%	153

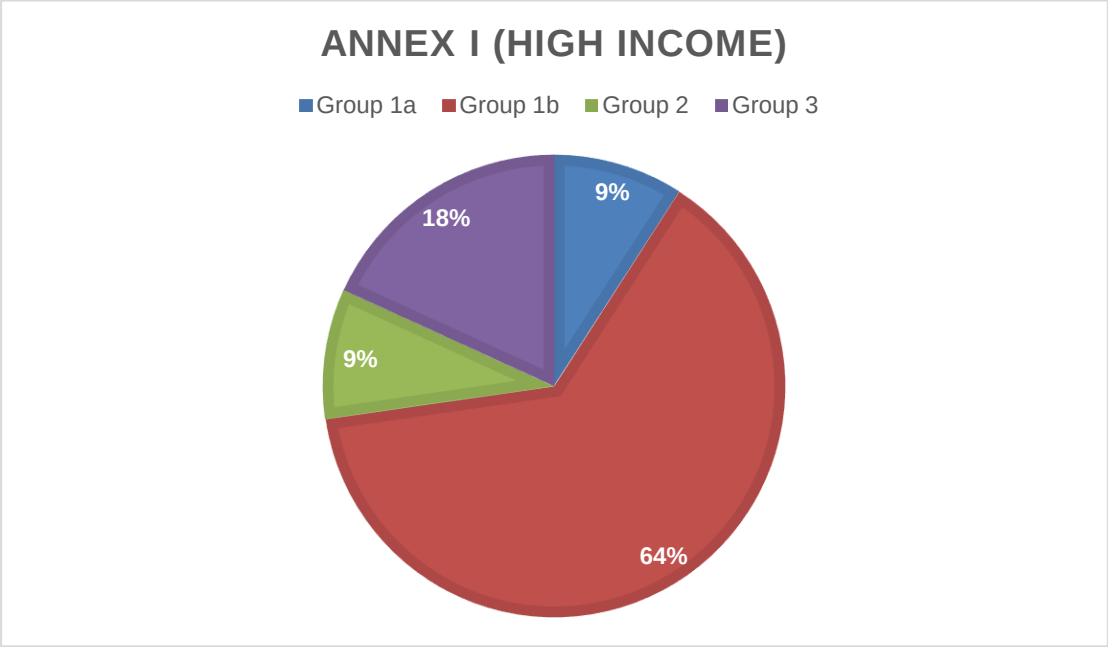


Figure 5 Annex I country groupings

[10] Note this includes the European Union as a single NDC instead of 27 individual Parties.

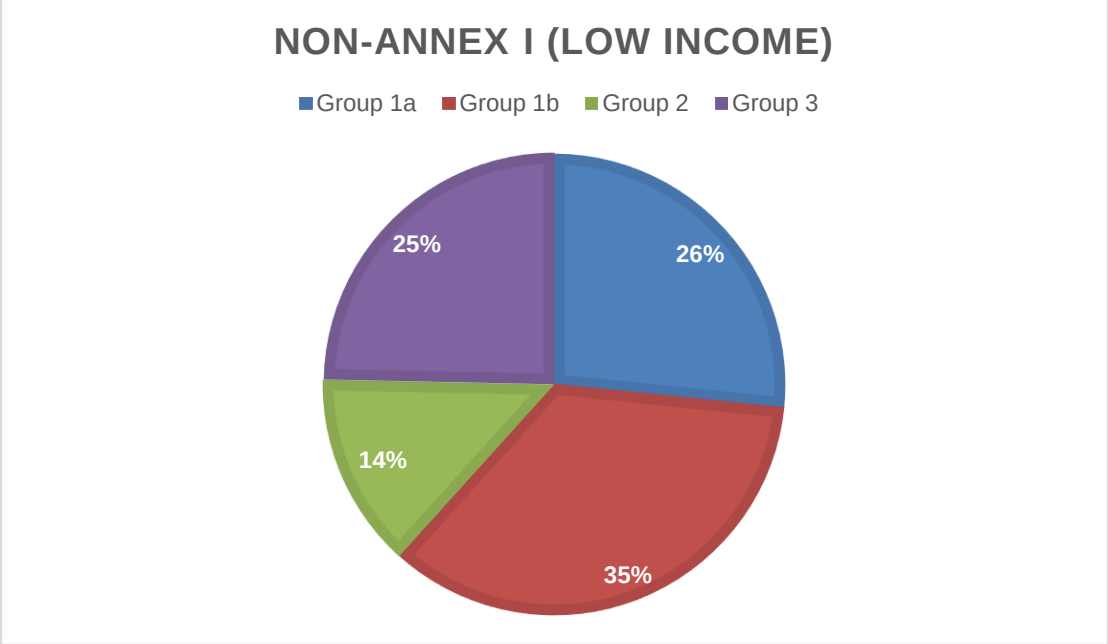


Figure 6 Annex I country grouping

4.6. Types of LULUCF contributions and mitigation targets

Countries that included the LULUCF sector used a range of different approaches in expressing their mitigation targets, from specific GHG emission targets relative to BAU emissions to just mitigation actions. Most NDC were expressed in GHG mitigation target (86 NDCs), followed by NDCs with just actions (15 NDCs), a mix of GHG and non-GHG targets (14 NDCs), and non-GHG targets (8 NDCs).

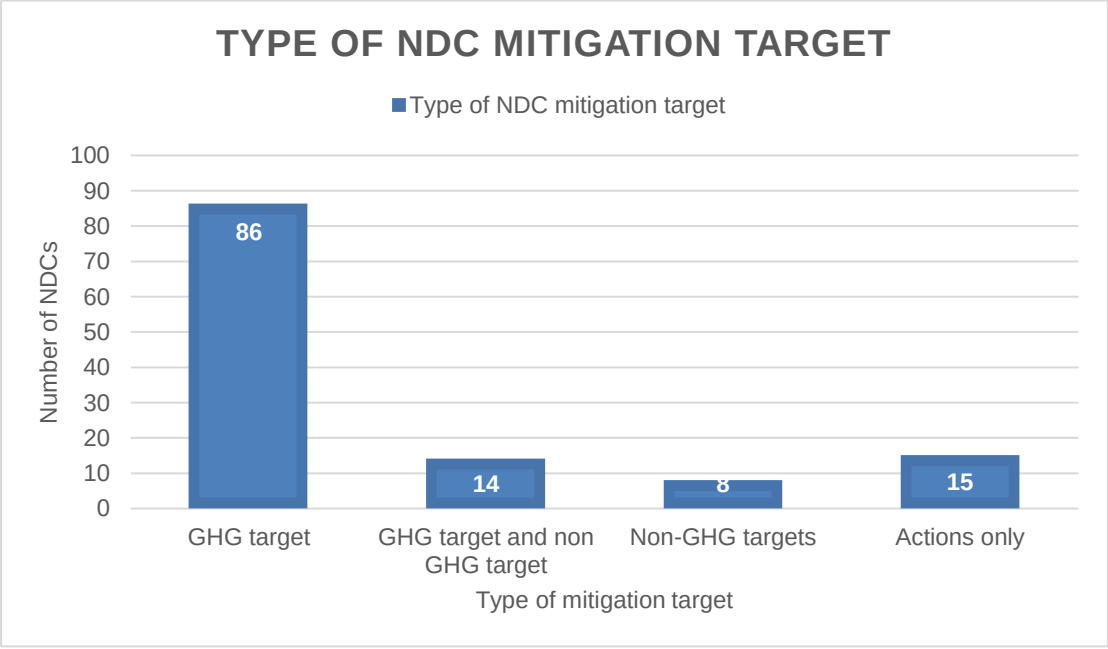


Figure 7 Type of NDC mitigation targets that included LULUCF (group 1 and 2).

The most frequent NDC type was a target to reduce GHG emissions related to a BAU scenario. Most countries did not provide information on their assumed approaches for estimating and accounting for LULUCF emissions and removals, however some stated their preference to account for LULUCF as part of any other sector (ie not apply specific accounting rules).

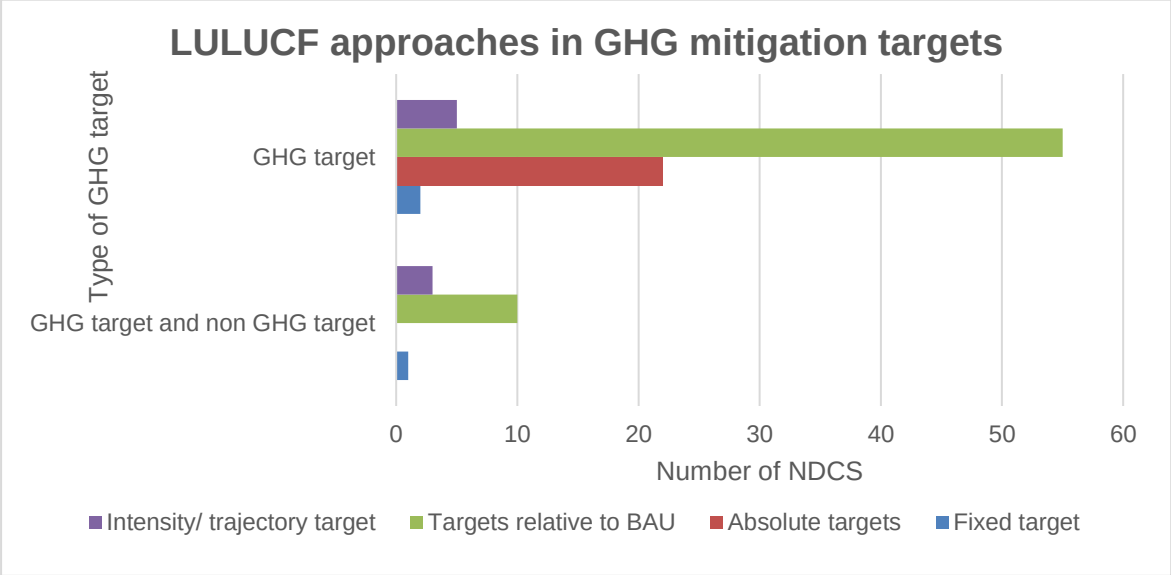


Figure 8 LULUCF approaches in GHG targets

The table below depicts the range of NDCs types and their LULUCF approach.

Table 11 Summary of mitigation targets and LULUCF approach. Adapted and updated from Grassi et al 2015.

Type of NDC mitigation target		**LULUCF approach(es)**	**Number of NDCs and examples**
GHG target **(86 NDCs)**	Absolute target relative to a base year (e.g. "*an economy-wide target to reduce GHG emissions by 26 to 28 percent 2005 levels by 2030*":, Australia)	Include LULUCF as part of any other sector	22 NDCs E.g. Australia, Japan and Canada
		Special accounting rules (e.g. net-net accounting) (12 NDCs)	
	Target relative to a BAU scenario (e.g. "*an economy-wide target to reduce GHG emissions by 26 to 28 percent 2005 levels by 2030*", Algeria)	Include LULUCF as part of any other sector	55 NDCs E.g. Bangladesh, Republic of Congo, Cambodia
		Specified target (10 NDCs)	
	Intensity or trajectory target (e.g. "*reduce GHG emissions intensity of GDP by 45% by 2030 relative*	Not provided/ unclear or will be provided at a later point	5 NDCs E.g. Sierra Leone, Singapore,

	to the emissions intensity of GDP in 2005", Malaysia)	Specified target (1 NDC)	Tunisia, Uruguay
	Fixed level target (e.g. "*limit net GHG emissions in 2030 to 145 Mt CO or lower*", Ethiopia)	Not provided/ unclear or will be provided at a later point	2 NDCs E.g. Costa Rica, Ethiopia
GHG target and non GHG target (14 NDCs)	Target relative to a BAU scenario (e.g. "*reduce unconditionally 26% of GHG against the BAU scenario by the year 2020; and a conditional target of 29% against BAU scenario*", Indonesia)	Not provided/ unclear or will be provided at a later point	10 NDCs E.g. Viet Nam, Indonesia, Panama, Burundi
		Specified target (5 NDCs)	
	Intensity or trajectory target (e.g. peaking of $C0^2$ around 2030 and best efforts to peak early; lower carbon dioxide emissions per unit of GDP from 2005 level, China)	Not provided/ unclear or will be provided at a later point	3 NDCs E.g. India, Chile, China
		Specified target (2 NDCs)	
	Fixed level target (e.g. "*remain carbon neutral where emission of GHG will not exceed carbon sequestration by forests, which is estimated at 6.3 million tons of CO_2*", Bhutan).	Specific LULUCF target	1 NDC Bhutan
Non-GHG targets and actions (8 NDCs)	Proposed targets and actions (e.g. "*By 2030, all remaining wetlands and watershed areas with carbon sequestration potential are protected as carbon sinks*." Antigua and Barbuda).	Not provided/ unclear or will be provided at a later point	8 NDCs e.g. Bolivia, Nepal,
		Specific or conditional target for LULUCF emission reductions (3 NDCs)	
Actions only (15 NDCS)	NDCs with no specific GHG target, but included actions in the LULUCF sector or a specific LULUCF or forestry target (e*.g. "To increase forest cover to 70% of land area (to 16.58 million hectares) by 2020".* Laos)	Not provided/ unclear or will be provided at a later point	15 NDCs E.g. South Sudan, Guyana, El Salvador

4.7. Conditionality of targets

Mitigation targets may include specific conditions for their implementation, such as access to climate finance, technology transfer, or capacity building support. Several NDCs that included the LULUCF sector indicated their mitigation targets or specific LULUCF

commitments were conditional upon receipt of international support and finance. In total, 49 NDCs provided conditional targets, with some specifying that additional LULUCF measures would be conditional on finance.

Table 12 Conditionality of mitigation targets, source: own analysis

Grouping	Conditional	Partially conditional	Both conditional & unconditional elements	Unconditional	Not specified
1. NDCs that include LULUCF					
1a. With explicit targets and measures	11	4	22	5	
1b. No listed targets and measures	17	3	23	13	6
2. NDCs that partly include LULUCF	10	1	9	2	
3. NDCs that exclude LULUCF.	11	5	15	4	5
Total	**49**	**13**	**69**	**24**	**11**

The most significant countries with LULUCF commitments that included conditional targets was India, Indonesia, Mexico, Nigeria, South Africa, and Malaysia. Although LULUCF is included in NDCs, the conditionality of targets raises some concerns about the feasibility of implementation and/or strength of target. More detailed provided in the Appendix Table 12.

4.8. Accounting approaches for LULUCF

While most countries intend to include emissions and removals from the LULUCF sector as any other sector (or did not yet specify accounting approaches), some countries indicated their land sector accounting approaches. These countries have played an influential role in shaping the LULUCF accounting system in the past and represent mostly Annex I countries (developed countries) or countries with high level of emissions.

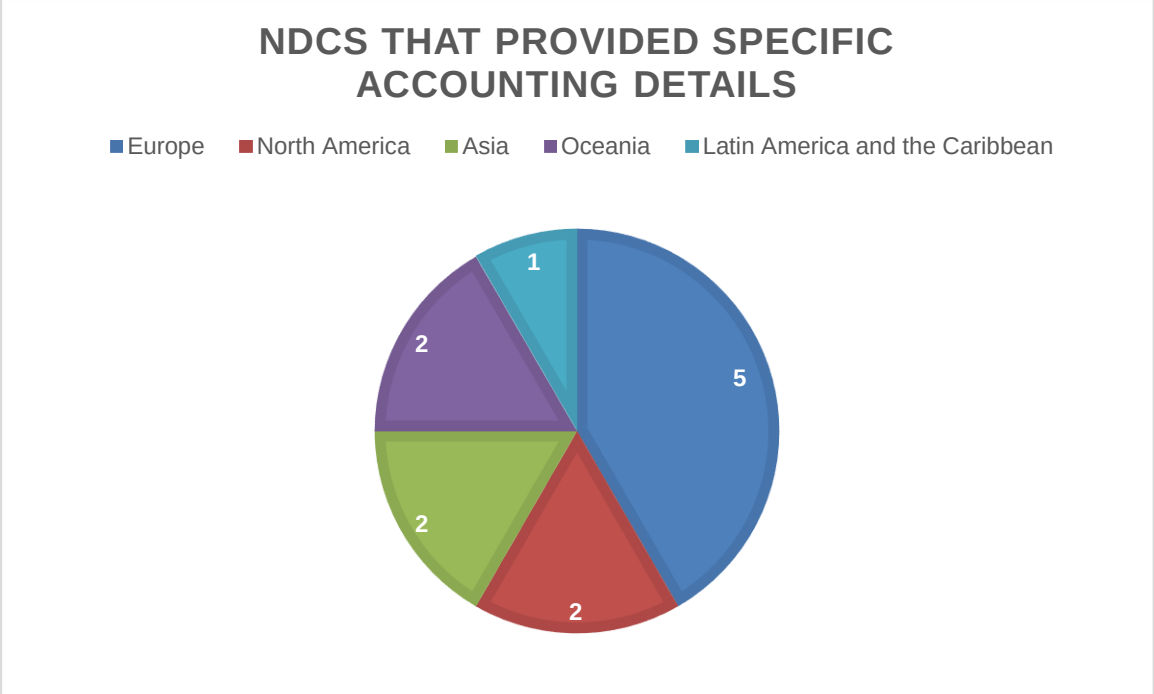


Figure 9 NDCs that provided specific accounting approaches

The degree of detail provided about accounting approach ranged between NDCs. Some specified that accounting would be decided later upon the finalization of a post-2020 common framework for land sector accounting. The diversity of accounting approaches is summarized in Table 13 below.

Table 13 Summary of LULUCF accounting approaches from NDCs

Country	Specified accounting approach
Australia	Accounting based on UNFCCC inventory reporting using a net-net approach. Apply IPCC guidance for treatment of natural disturbances and variation.
Canada	Account for the land sector using a net-net approach.
EU28 Member States	Assumed Kyoto Protocol accounting rules: Comprehensive accounting framework, activity or land-based approach, for emissions and removals from land use, land-use change and forestry.
Japan	Removals by LULUCF sector are accounted in line with approaches equivalent to those under the Kyoto Protocol
New Zealand	Assumed-Kyoto Protocol accounting rules and accounting for harvested wood products based on the production approach.
Norway	Undecided - possibility of applying the Kyoto Protocol rules for natural disturbances and carbon stock changes in harvested wood products. Final approach will be decided upon later based on dialogue with the EU.
Republic of Moldova	Account for the land sector using a net-net approach; and to use a production approach to account for harvested wood products.
Switzerland	Assumed Kyoto Protocol rules: Land based approach with reference level for forestland. Accounting is yet to be defined for 2021-2030 (currently a study on non-forest land reporting is on-going).

Turkey	Assumed Kyoto Protocol rules with gross-net accounting for forests.
Ukraine	Assumed Kyoto Protocol rules: "An approach to including the land use, land-Use and forestry in the climate change mitigation structure will be defined as soon as technical opportunities emerge, but no later than 2020"
United States	Account for the land sector using a net-net approach; and to use a production approach to account for harvested wood products consistent with IPCC guidance. May also exclude emissions from natural disturbances, consistent with available IPCC guidance.
Venezuela	Accounting relative to a projection of net emissions in the target year (forward-looking baseline).

Analysis of specific groups:

4.9. Group 1: LULUCF included

The NDCs that included the LULUCF sector in mitigation contributions was divided into those that provided specific LULUCF measures and policies (42 NDCs) and those that did not list any policies or measures (63 NDCs).

Group 1A: included specific measures and policies		
Number of NDCs	42	
Type of mitigation target	Actions only	22,5%
	GHG target	62,5%
	GHG and non-GHG targets	12,5%
	Non-GHG target	2,5%
Conditionality of target	Conditional and unconditional	22 NDCs
	Conditional target	10 NDCs
	Partially conditional targets	4 NDCs
	Unconditional target	6 NDCs
Global GHG emissions	21 20622 $MtCO_2e$ or 44.24% of global GHG emissions	
Land-Use Change and Forestry emissions ($MtCO_2$)	108.59 or 4% of all global LUCF emissions	
Forest area (sq km)	17 837 344.7 or 45% of global forest area	

NDCs that provided detailed information regarding LULUCF commitments included a range of intended policies and measures. The most frequent policy measure were afforestation and reforestation, followed by sustainable forest management and deforestation. NDCs that listed specific policies and measures came from a range of countries, mostly from the African

continent, followed by Asia. Half of the NDCs are classified as non-Annex I countries or Least Developed Countries.

As countries have listed policies and included specific targets, it is possible to quantify and measure the impact of the LULUCF sector in their NDCs. For example, Indonesia's Forestry moratorium policy is estimated to make largest mitigation contribution by reducing carbon at 188MtCO2e/year. If measures were strengthened (to include secondary forest and to remove existing licenses on palm oil, timber plantation and mining concessions), the potential carbon removal is estimated at 437MtCO2e/year.

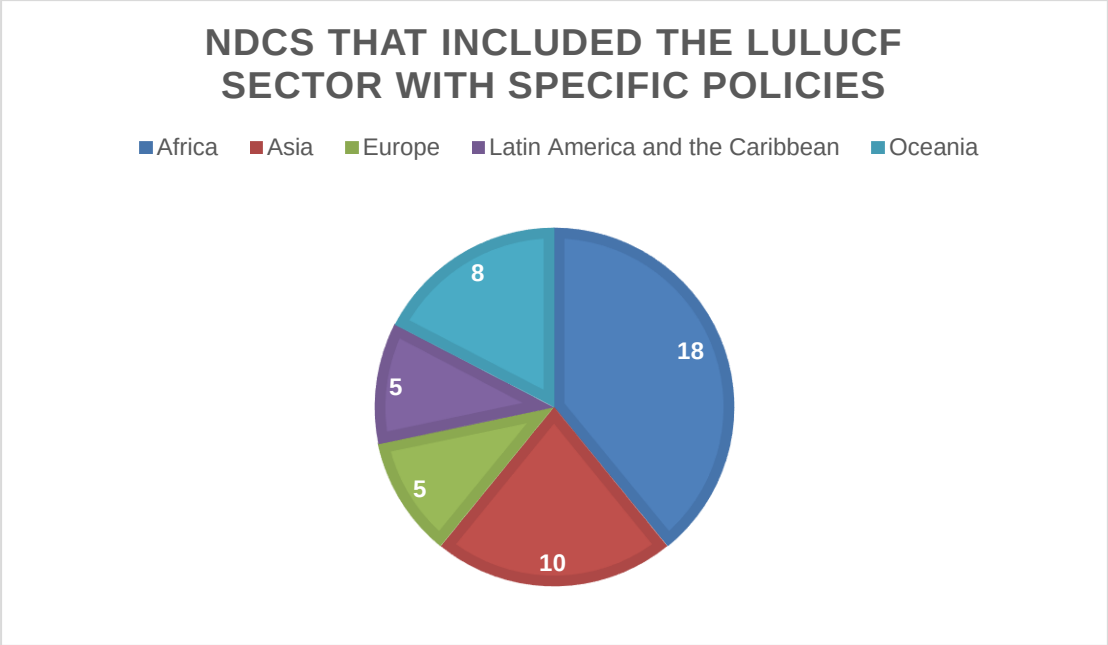


Figure 10 Geography of NDCs that included specific LULUCF policies and measures. Source: own analysis

Amongst the NDCs that included LULUCF, 25 NDCs included specific LULUCF mitigation targets (some containing multiple targets). Most of these targets related to the forest sector, such as increasing forestland through afforestation or reforestation, sustainable forest management or reducing deforestation.

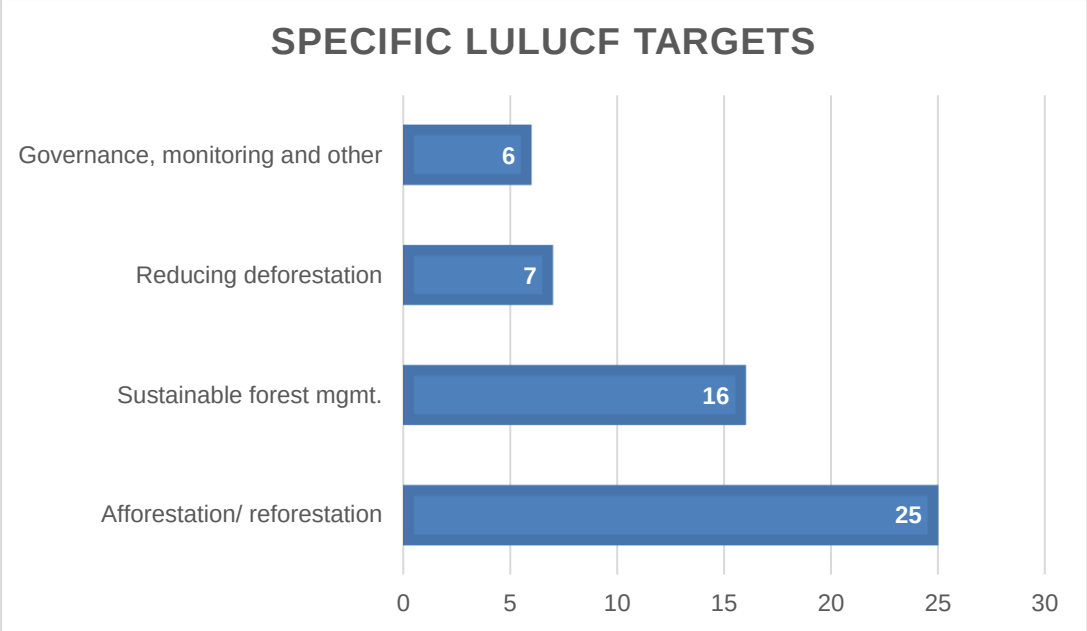
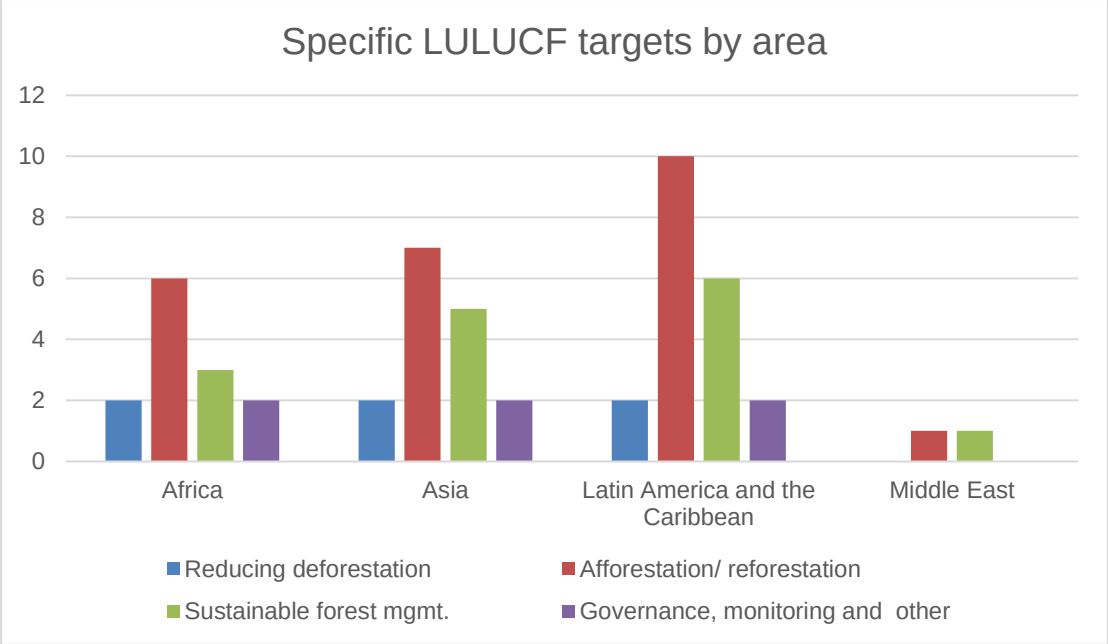


Figure 11 Type of LULUCF targets. Source: own analysis

Countries used quantitative as well as qualitative targets, which were expressed as expanding forestland in hectares, as well as in terms of CO_2 or GHG emission reductions. For example: Cabo Verde: "*an unconditional long-term commitment to engage in new afforestation/reforestation in the order of 10,000 hectares by 2030, or with international support, 20,000 hectares until 2030, and an estimated planting effort of 400 trees per hectare*." For Japan, the "*target for removals is set as approximately 37 million t-C02, corresponding to 2.6% reduction of total emissions in FY 2005. Within this target, approximately 27.8 million t-C02 by forest carbon sinks measures (corresponding to 2.0% of total emissions in FY 2005); and approximately 9.1million t- CO_2 by cropland management, grazing land management and revegetation, corresponding to 0.7% reduction of total emissions in FY2005*". This diversity of approaches makes aggregating or comparing the impact of policies and NDCs between countries difficult. The figure below summarizes the range of targets proposed in countries NDCs by area.



Reducing emissions from deforestation and forest degradation in developing countries program (also known as REDD+) is a results-based payment programme that aims to incentivize developing countries to maintain their forestland. REDD+ was referred to as a key mitigation strategy in 29 NDCs.[11] While REDD+ is not the focus of this research, the Paris Agreement mentions the use of and promotes sustainable forest management as a policy approach and as a positive incentive to reduce emissions and enhance forest stocks (Article 5.2).

Most countries in this group emphasized the importance of the LULUCF sector as a mitigation strategy. Namibia and Ethiopia stated that emission reductions from the LULUCF sector are expected to make the largest contribution to mitigation targets, e.g. 18 513Gg CO_2eq or 81.7% BAU scenario in 2030 (Namibia). Likewise, many countries also stated that the LULUCF sector was the largest source of emissions. Although the LULUCF sector will continue to become a large source of emissions from forestry (e.g. 78% in 2015 and 65% in 2040 for Malawi), more countries expect the LULUCF sector to gradually become smaller source of emissions and eventually function as an emissions sink over time (e.g. Gabon).

[11] Belize, Cambodia, Cameroon, Chad, Costa Rica, DRC, Ivory Coast, Fiji, Ghana, Guatemala, Guyana, Indonesia, Lesotho, Liberia, Madagascar, Nepal, PNG, Peru, Philippines, Republic of Congo, Rwanda, St Vincent and the Grenadines, Sierra Leone, Sudan, Tanzania, Timor-Leste, Thailand, Togo, and Zimbabwe

Despite the diversity, some of the NDCs in this group represent the largest global emitters. Amongst those that listed specific policies and measures were the top ten highest emitters: China, India, Indonesia, Brazil, Japan and South Africa.

Table 14 Top ten global GHG emissions from Group 1A

Country	Total GHG Emissions Excluding LUCF (MtCO2e)	Total GHG Emissions Including LUCF ($MtCO_2e$)	% of global emissions	Ranking for global GHG emissions
China	10 975,5	10684,29	22.44	1
India	3 013,77	2887,08	6.07	4
Indonesia	760,81	1981	4.16	6
Brazil	1012,55	1823,15	3.83	7
Japan	1344,58	1207,3	2.54	8
South Africa	462,6	463,75	0.9	16
Algeria	187,33	189,08	0,47	36

This group also included the countries with the largest forest cover and highest change in forest cover for the past ten years. The three countries that are expected to make the largest LULUCF contribution were included in this group: Brazil, Indonesia and Democratic Republic of Congo. Grassi identified these countries as relevant countries in terms of the magnitude of their LULUCF contribution, due mainly to the substantial emission reductions from reduced deforestation in these countries (Grassi et al. 2017).

4.10. Group 1B: LULUCF included with no specific measures and targets in NDCs

Most of the NDCs that include LULUCF in their mitigation target did not provide policies, measures or specific targets for the sector. As a whole, this group contributes a third of global GHG emission and includes a breadth of countries, mostly from Africa and Asia. Most developed countries fall into this group.

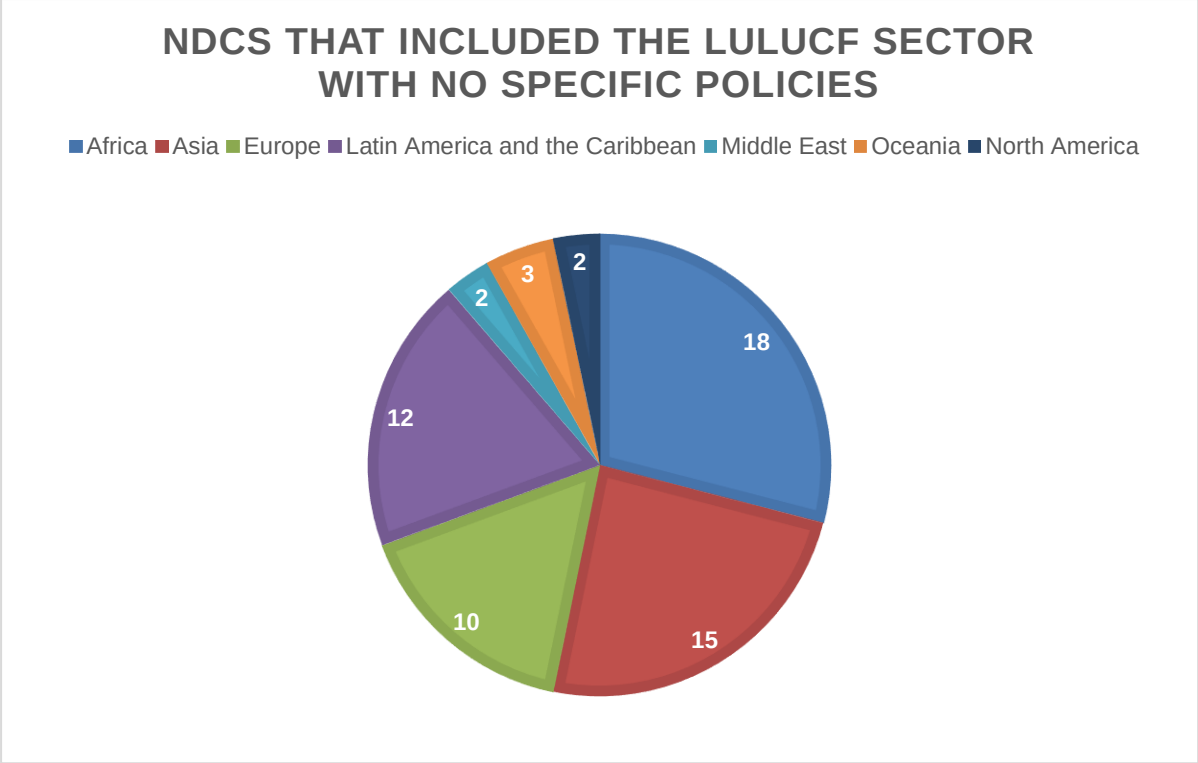


Figure 12 NDCS that include LULUCF with no specific policies

Figure 13 Details on Group 1B: no specific policies or measures

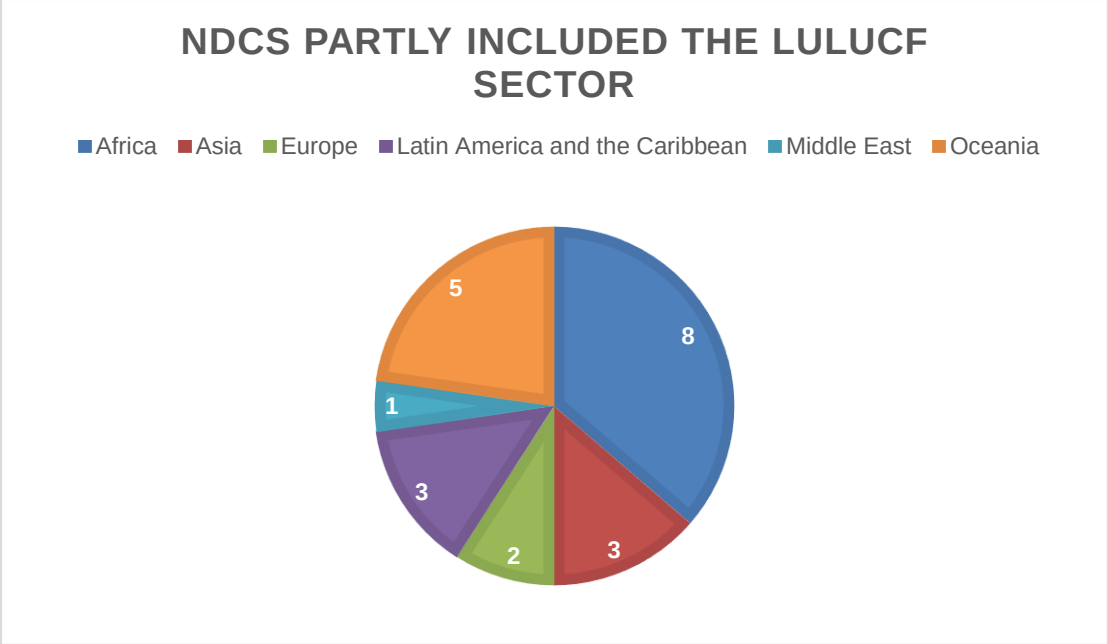
Group 1B: no detail on policies and measures	
Number of NDCs	63
Type of mitigation target	Actions only: 6 NDCs (10%) GHG target: 50 NDCs (81%) GHG and non-GHG targets: 4 NDCs (6%) Non-GHG target: 2 NDCs (3%)
Conditionality of target	Conditional and unconditional: 24 NDCs (39%) Conditional target: 16 NDCs (26%) Partially conditional targets: 3 NDCs (5%) Unconditional target: 13 NDCs (21%) Not specified: 6 NDCs (10%)
Global GHG emissions (CO_2e)	15 172,18Mt CO_2e or 31.94% of global GHG emissions
Land-Use Change and Forestry emissions (Mt CO_2)	453.6951 or 17% of global LUCF emissions

Forest area (sq km)	8 436 451 or 21% of global forest

The most prominent feature of this group is the number of NDCs that provided information on the intended accounting approaches. Half of the NDCs that provided accounting details used to estimate and measure LULUCF emissions were in this group.

4.11. Group 2: LULUCF partly included in NDC

There were 22 NDCs that partly included LULUCF, but were not clear about how LULUCF was covered in mitigation targets or defined the sector ambiguously. A majority of these NDCs were from Africa or Oceania.



Most of these NDCs included the LULUCF sector in separate targets or included specific policies and measures, but excluded the sector from the mitigation target. For example, Ecuador pledged an energy only GHG target, and included a separate forest target, whereas Chile excluded the LULUCF sector from the mitigation target entirely, but included a separate target for the forestation sector of 100,000 hectares. The Gambia and St Lucia excluded LULUCF from baseline projection because of the high degree of uncertainty, but still included separate climate targets for the sector. Many countries raised issues of capacity and difficulties finding the sufficient data required to estimate emissions and removals from the sector. In order to include LULUCF in the future, some mentioned the need for greater precision in measuring emissions from the sector and development of the emissions registry (e.g. Bangladesh, Cameroon, Cote de Ivor, Guinea, Georgia). Many NDCs in this group had conditional targets and indicated that the sector would be included pending international

support and finance (Djibouti). For some NDCs, the decision to include LULUCF will be decided by 2020 (EU and Thailand).

Group 2: partly include the LULUCF sector	
Number of NDCs	22
Type of mitigation target	Actions only: 4 NDCs (18%) GHG target: 9 NDCs (41%) GHG and non-GHG targets: 6 NDCs (27%) Non-GHG target: 3 NDCs (14%)
Conditionality of target	Conditional and unconditional: 9 NDCs (41%) Conditional target: 10 NDCs (45%) Partially conditional targets: 1 NDC (5%) Unconditional target: 2 NDCs (9%
Global GHG emissions (CO2e)	15 172,18Mt CO2e or 31.94% of global GHG emissions
Land-Use Change and Forestry emissions (MtCO2)	453.6951 or 17% of global LUCF emissions
Forest area (sq km)	8 436 451 or 21% of global forest

The most significant emitter in this group is the European Union. As the largest emitter, the EU also represents some of the most forested land. The LULUCF sector in the EU represent a net sink, however projections indicate that the sink will decrease in the future. Policies on the methodology and coverage of LULUCF emissions into 2030 GHG mitigation targets will be established "*as soon as technical conditions allow and in any case before 2020*" (EU 2015). In 2016, the European Commission proposed regulations for how LULUCF should be included. The proposal creates a separate legislative framework for LULUCF but EU members are allowed to offset some of emissions using forestry credits in the effort sharing regulation (which regulates non-ETS emissions) (Böttcher and Graichen 2015; European Commission 2016)

Given the range of different approaches to include LULUCF in this group, it is difficult to assess the ambition and stringency of the LULUCF commitments in this category. As indicated in NDCs, some countries intend to take steps to include LULUCF in the future so it is likely that more countries will provide clearer information as to

4.12. Group 3: LULUCF sector is excluded in NDC

Nearly a quarter of NDCs (40 NDCs) did not include the LULUCF sector, most of which were small island states in Oceania, such as Fiji and the Cook Islands, or the Middle East such as Iran, Saudi Arabia, Egypt. The geographic spread is provided in the figure below:

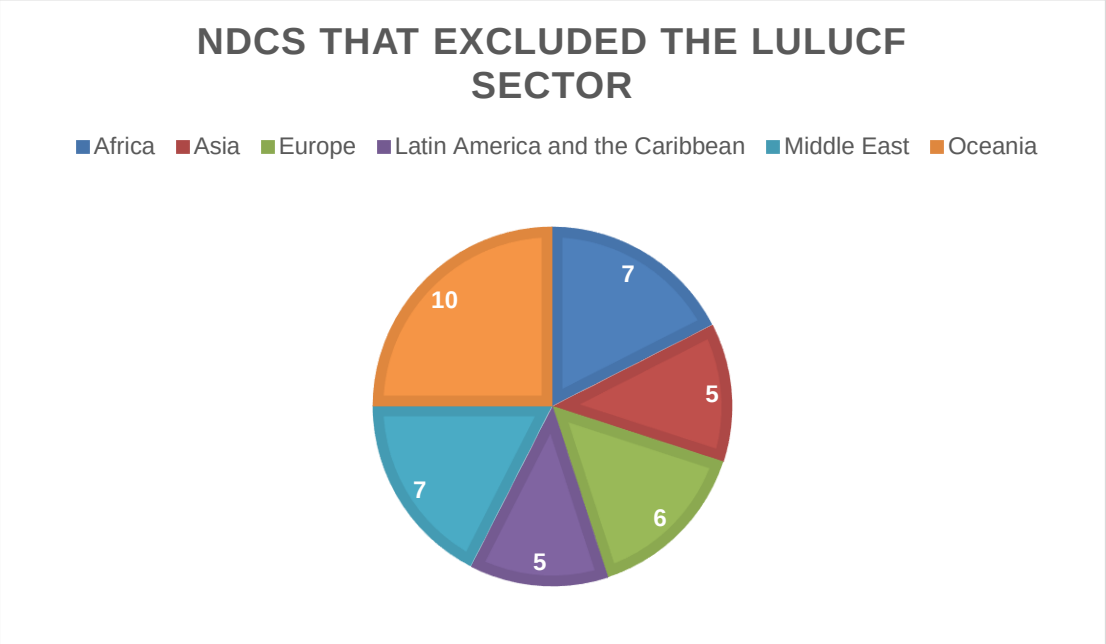


Figure 14 NDCs that excluded LULUCF sector

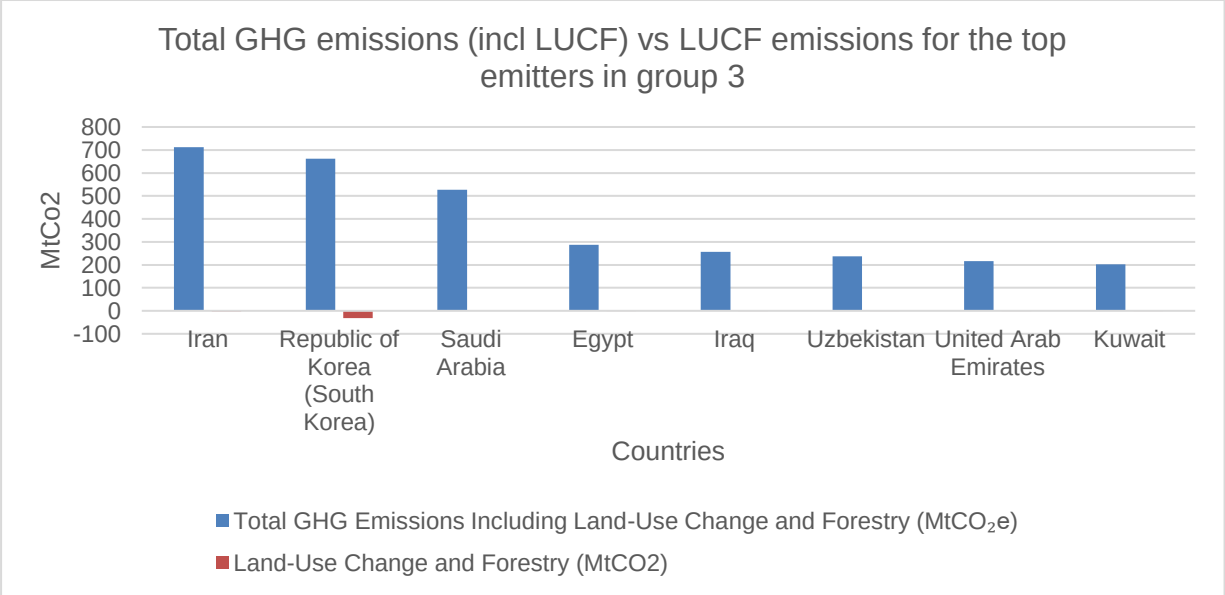
In terms of total GHG emissions (Including Land-Use Change and Forestry), this group contributes 3821.9477 $MtCO_2e$, or roughly 8% of global GHG emissions (in 2012).[12] The most significant emitters in this group were Iran, South Korea and Saudi Arabia. For many countries within this group, the LULUCF sector acts as a net sink, rather than a source of emissions (e.g.. Niue, St Lucia, Seychelles and Liberia). The cumulative LULUCF emissions for group 3 are -49.5081 (MtCO2). Countries in this category also have relatively fewer forestland.

Group 3: excluded the LULUCF sector		
Number of NDCs	40	
Type of mitigation target	Actions only	9 NDCs (23%)
	GHG target	25 NDCs (63%)
	GHG and non GHG targets	5 NDCs (13%)
	Non-GHG target	1 NDCs (3%)

[12] Emissions for Andorra, the Marshall Islands, Micronesia, Monaco, and Tuvalu were not included in this total because of lack of data. Global GHG data is from World Resources Institute.

Conditionality of target	Conditional and unconditional	15 NDCs (38%)	
	Conditional target	11 NDCs (28%)	
	Partially conditional targets	5 NDCs (13%)	
	Unconditional target	4 NDCs (10%)	
	Not specified	5 NDCs (13%)	
Global GHG emissions (CO2e)	3789.99 MtCO2 or 7.98 % of global GHG emissions in 2012		
Land-Use Change and Forestry emissions (MtCO2)	-49.51 MtCO2 or -2% of global LUCF emissions		
Forest area (sq km)	7 294 696 or 18% of global forest area		

Table 15 Group 3: excluded the LULUCF sector



There were three main reasons given to explain why countries have excluded LULUCF. Firstly, the lack of data and uncertainty with estimating emissions. Montenegro and St Lucia cited the "relatively high degree of uncertainty in developing projections of sources and sinks" in the sector as why the LULUCF sector was excluded. Based on initial information, St Lucia estimated that the LULUCF sector could contribute an additional 4% emission reduction relative to BAU by 2030. Secondly, many countries (e.g. Macedonia, Micronesia and Trinidad and Tobago) noted the relatively small, sometimes negligible, role of LULUCF in the share of national GHG emissions. For some countries, such as Seychelles, the opportunities to reduce emissions in LULUCF are limited and costly. Hence, it is more pragmatic to focus on energy and transport sectors as the highest contributors to GHG emissions. Lastly, some stated that decisions to include LULUCF will be made at a later stage after methodologies to

estimate emissions and removals in the sector are clarified, e.g. South Korea. Countries such as Albania, Montenegro and Belarus noted that the LULUCF sector might be included in subsequent NDCs, pending the availability of sufficient data and improved technical conditions. Fiji acknowledged that further accounting needed to include the sector [mitigation potential of forestry via REDD+ mechanisms.

Many NDCs in this group did not mention the LULUCF at all and mainly focused on mitigation targets for the energy sector – expressed as actions only as well as GHG and non-GHG targets. Most of these NDCs were small island countries, such as Andorra, Cook Islands, Cuba, Jamaica, Maldives, Kiribati, Marshall Islands, Micronesia, Nauru, Niue, Palau, and Tuvalu. Some NDCs, such as Kuwait, Iran, Iraq and Israel, focused on energy, industrial processes, and waste sectors. Barbados stated that LULUCF emissions were included in establishing its BAU projections, however did not include any specific LULUCF commitment.

4.13. Testing the hypothesis

According to the forest transition theory, we expect countries to treat LULUCF targets within their NDCs in accordance with their stage in forest transitions. Countries which are expected to benefit from forest transitions (in terms of emissions reduction) would be more likely to set up clear and ambitious LULUCF targets than countries for which forest transitions are less relevant. NDCs with the clearest and most ambitious LULUCF targets were categorised in Group1a: NDCs that specified policies, measures and specific targets. The more significant NDCs in this group are Brazil and Indonesia. Brazil in particular was the only non-Annex I country to pledge an absolute emissions reduction target to: reduce greenhouse gas emissions by 37% below 2005 levels in 2025. In its NDC, Brazil also listed specific measures such as strengthening the Forest Code, restoring and reforesting 12 million ha of forests by 2030, limiting illegal deforestation in the Amazon, enhancing sustainable native forest management system and introduced a target for zero illegal deforestation by 2030. Brazil also committed to increasing their share of non-hydropower renewables in its energy mix

Table 16 Coverage of global forestry for top ten significant forest countries

	Country	Forest area (thousand ha) [13]	% of land area	% of global forest area	LULUCF grouping
1	Russia	8 149 305	50	23	Group 1B
2	Brazil	4 935 380	59	12	Group 1A
3	Canada	3 470 690	38	9	Group 1B
4	United States	3 100 950	34	8	Group 1B
5	China	2 083 213	22	5	Group 1A
6	Democratic Republic of Congo	1 525 780	67	4	Group 1A
7	Australia	1 247 510	16	3	Group 1B
8	Indonesia	910 100	53	2	Group 1A
9	Peru	739 730	58	2	Group 1B
10	India	706 820	24	2	Group 1A
	Total	2 686 948			

Conversely, countries that did not include LULUCF in their mitigation target (group 3) represented countries with either low forest cover or insignificant LULUCF emissions.

The table below shows the countries that represent the top ten contributors to global GHG emissions and their relative GHG emissions:

	Name	Total GHG Emissions Excluding LUCF (MtCO2e)	Total GHG Emissions Including LUCF ($MtCO_2e$)	% of global emissions	LUCF (MtCO2)	LULUCF Grouping
1	**China**	10975,5	10684,29	22,44	-291,21	Group 1a
2	**United States**	6235,1	5822,87	12,23	-412,23	Group 1b
3	**EU28 Member States**	4399,15	4122,64	8,66	-276,51	Group 2
4	**India**	3013,77	2887,08	6,06	-126,69	Group 1a
5	**Russia**	2322,22	2254,47	4,73	-67,74	Group 1b
6	**Indonesia**	760,81	1981	4,16	1220,20	Group 1a
7	**Brazil**	1012,55	1823,15	3,83	810,59	Group 1a
8	**Japan**	1344,58	1207,3	2,53	-137,28	Group 1a

[13] FAO Stat 2015

9	**Canada**	714,12	856,28	1,79	142,16	Group 1b
10	**Mexico**	723,85	748,91	1,57	25,06	Group 1b

The figure below shows the land-use change and forestry (LUCF) emissions for the top ten global GHG emitters, showing that the land use sector functions as a significant source of GHG emissions for some countries, and a sink for others.

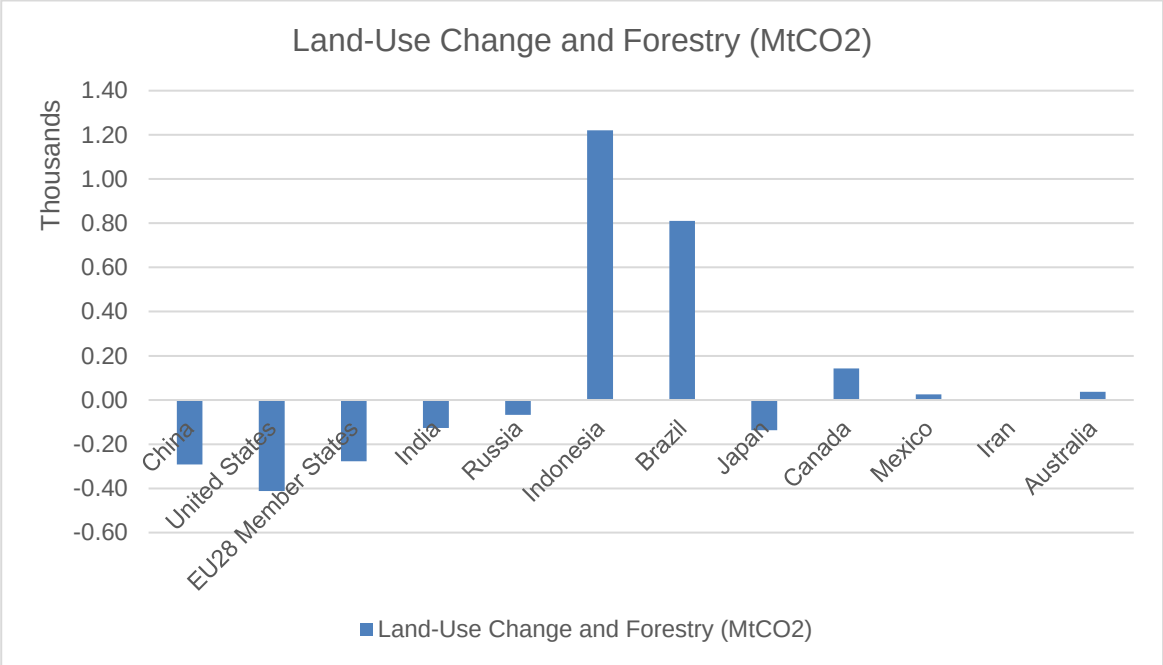


Figure 15 Land-Use Change and Forestry emissions for top ten global GHG emitters. Source: FAO Stat and WRI CAIT, 2015

Comparing total GHG emissions (including LUCF emissions) against sectorial emissions from LUCF, shows that the LULUCF sector acts as a sink for the five top GHG emitters (China, US, EU28, India and Russia). Only China and India provided specific policies and measures for LULUCF. For Indonesia, Brazil, Canada and Australia, LULUCF represents a source of emissions (particularly for Indonesia and Brazil).

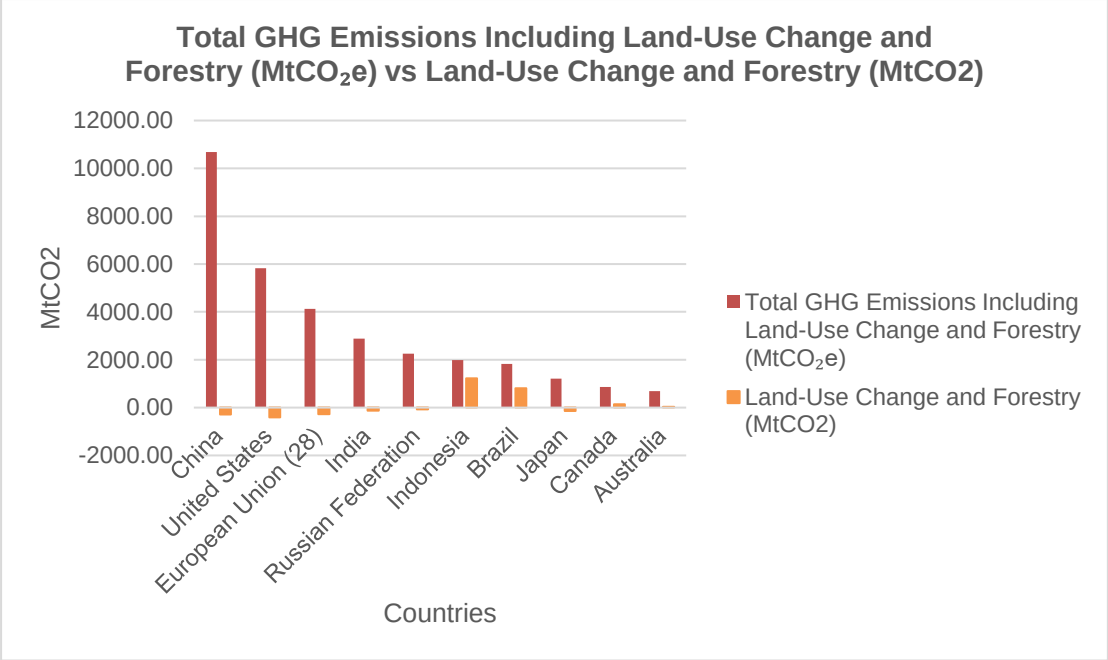


Figure 16 Total GHG emissions (incl LUCF) versus LUCF emissions

Supporting this, we also expect countries to treat LULUCF targets within their NDCs in accordance with their national economic structures. This means that countries with high levels of GDP are more likely to include LULUCF measures. This can reflect the need to signal their commitment to climate action and ambition, without impairing their economic interests, or because of the mitigation potential of the LULUCF sector as it represents a net sink. Looking at the GDP per capita on the NDCs assessed, nearly all of them included LULUCF, however not with specific policies or targets.

Table 17 GDP per capita and LULUCF grouping

	Country Name	GDP per capita (**2016**)	LULUCF grouping
1	Switzerland	79887,51824	Group 1B
2	Norway	70867,94061	Group 1B
3	Iceland	60529,92676	Group 1B
4	Qatar	59324,33877	Group 3
5	United States	57638,15909	Group 1B
7	Singapore	52962,49157	Group 1B
8	Australia	49755,31548	Group 1B
9	San Marino	47908,56141	Group 1B
10	Canada	42348,94546	Group 1B

4.14. Conclusion

A total of 105 NDCs included the LULUCF sector, with just under half providing specific policies and measures (42 NDCs). While the LULUCF sector is included as a sector in mitigation contribution in most NDCs, the coverage and information provided NDCs vary immensely, with inconsistent and sometimes incomparable approaches. The lack of information or quality data to include the LULUCF sector highlights a lack of capacity in some developing countries.

However, focusing attention to NDCs of countries that are high emitters and have significant forest land cover reveals a more interesting dynamic as to how these countries have included LULUCF in their NDCs. In terms of the hypothesis proposed, the results of the categorization generally fit with the assumptions. However, further analysis is required to strengthen these generalisations and findings.

5. Discussion and analysis

This chapter discusses the results of grouping NDCs according to their LULUCF treatment in order to gain insights into how countries' NDCs reflect their national circumstances, in particular the linkages back to the research problem, objectives and the relevant theory and literature.

5.1. Research problem and objectives

This thesis evaluated the LULUCF components of 166 NDCs in order to gain insights into how NDCs reflect the national circumstances and capabilities of countries. Assessing NDCs generated an abundance of information about the mitigation priorities and intended climate actions of countries. The categorization resulted in some surprising and unusual groupings of countries - beyond the traditional Annex I and non-Annex I divide, or developed and developing country dichotomy usually seen in the UNFCCC. The results revealed groupings of countries, which are uncommonly grouped together, but were thought to have similar interests. For example, Group 1B (NDCs that include LULUCF but do not specify measures or targets) featured the highest number of NDCs with a wide geographic coverage and across all income levels. This is presumably because Group 1B presented the least-cost option for countries with sufficient capacity; a large of number of NDCs included the LULUCF sector but did not need to include specific measures or targets which might bind them in the future.

The wide coverage of global forest cover and GHG emissions reinforces that LULUCF is an important and necessary mitigation option. Although Group 1B had the largest number of NDCs, the group that represented the largest global GHG emissions was Group 1A, representing 37% of all global GHG emissions. Group 1A featured a wide range of targets and measures, although some were more detailed and ambitious than others. The level of information provided in these NDCs allows for a greater understanding of the impact of the LULUCF sector and the impact of the NDC as a whole.

The group with the greatest diversity and ambiguity was Group 2: NDCs that partially included the LULUCF sector. This is because there was no consistent way that countries included the LULUCF sector. The number of NDCs and variety of national circumstances in Group 2 can be interpreted as countries who plan on using LULUCF but have not yet fully decided or committed to how LULUCF activities will contribute to meeting their mitigation

targets. Many NDCs in this group alluded to making decisions on including the LULUCF sector later or when the methodologies to estimate emissions and removals are clarified.

Without measurable targets or specific policies it is difficult to assess whether the impact of LULUCF commitments represent shifting ambition or whether they are political signals in the climate regime. This produces more questions about the motivations of countries in the use of LULUCF sector. On one hand, countries may wish to use LULUCF activities to help meet their climate mitigation target, but it could also be interpreted as a political function and symbolic signal (echoing the findings from Røttereng 2018).

For NDCs in Group 3 (excluded the LULUCF sector) most of these countries acknowledged the influence of their own national circumstances (e.g. limited natural forestry resources and relatively minimal LULUCF contribution to global GHG emissions). One exception is South Korea was has substantial forest stock and global GHG emissions, however its NDC mentioned that LULUCF would be considered in time. As my results reflect the first iteration of NDCs, the results of this NDC grouping will most likely change in the future as countries increase capacity, either by developing methodologies for estimating and measuring LULUCF emissions, collecting sufficient data and receiving international support in the form of climate finance or technology transfer. In addition, many NDCs included specific conditions on their NDCs and their LULUCF commitments. While lack of capacity and finance is a key barrier to the implementation of NDCs, it does raise issues of the viability of mitigation targets and highlights major capacity building needs.

From this analysis, there are also some linkages between LULUCF treatment and the type of mitigation target. The type of mitigation target is inherently linked to the economic structures and classifications of countries in the UNFCCC. The Paris Agreement states that developed countries should continue undertake economy-wide absolute emission reduction targets, whereas developing country Parties are encouraged to move over time towards economy-wide emission reduction or limitation targets in the light of different national circumstances (UNFCCC 2015a).

5.2. Key trends

It is evident that while there are multitude of different approaches to including the LULUCF sector. Although it is difficult to make specific comments given the diversity of countries in each group, I can provide generalisations based on the assessment of NDCs, which reveal

some broad trends that are consistent with the theories identified earlier. There are three main narratives that emerge from how countries have included the LULUCF sector.

1. **Countries use LULUCF dependant on their national economic structures and resource endowments.**

Countries with large areas of forest, where the LULUCF sector could either represent a sink or source of emissions, include the LULUCF sector in their NDCs. The caveat to this generalisation is the EU28 who indicated that decisions would be made prior to 2020. This is presumably because more time was needed to make the necessary decisions given the complex negotiations and decision making processes within the EU (Böttcher and Graichen 2015; Parker, Karlsson, and Hjerpe 2017).

2. **Where relevant, countries will use LULUCF as a sink for emission reductions**

There are 13 NDCs from Annex I countries (the EU counts as a single NDC) included in this assessment. Only 2 NDCs (Monaco and Belarus) excluded the LULUCF sector, however Belarus indicated that decisions to include LULUCF will be determined after 2020, after clarifying methodologies related to estimating emissions and removals of GHG. All other NDCs included the sector, with Japan providing specific targets and estimates for proposed measures for reducing emissions from LULUCF. For most Annex I countries, the LULUCF sector acts as a sink, removing -814.01 MtCO2 from the atmosphere.[14] In addition, all Annex I countries specified accounting rules that could be used to estimates and measure LULUCF emissions and reductions in NDCs. As stated by the literature, these rules can significantly impact the overall ambition and headline progress of countries. Furthermore, countries with high emissions are generally likely to use LULUCF as a strategy to help them meet mitigation targets. From the results, most of the twenty highest global GHG emitters have included, or partially included LULUCF. The exception to this is South Korea and Saudi Arabia. However South Korea indicated it might include LULUCF and Saudi Arabia has relatively low forest cover.

3. **Countries include LULUCF as a significant source of emissions**

For many developing countries/non-Annex I Parties, the LULUCF sector represents a significant source of emissions, and therefore represents important mitigation strategy to reduce GHG. The two NDCs that promotes LULUCF as the largest mitigation potential was

[14] The exception however is Canada (which LULUCF contribute 142,16MtC02 of emissions), which warrants further analysis.

Indonesia and Brazil. These two countries also have the most significant LULUCF contributions as well as ambitious emissions reductions targets. Many of countries that have large forestry areas also represent countries undergoing a forest transition. These are represent emerging economies and warrant further research, especially in Sub-Sahara Africa where their energy profiles are likely to shift alongside economic growth and forest transitions.

5.3. Link to theoretical hypothesis

In examining why countries use LULUCF, the hypotheses outlined earlier provide some useful insight into the impact of national circumstances. The forest transition theory proposes countries treat LULUCF targets within their NDCs in accordance with their stage in forest transitions and that countries which are expected to benefit from forest transitions (in terms of emissions reduction) are be more likely to include LULUCF sector than countries for which forest transitions are less relevant. This hypothesis broadly supports point (3) about countries undergoing a forest transition that are more invested in LULUCF measures for climate mitigation.

From this analysis, one can infer that countries that include LULUCF, but not specify measures or provide quantifiable targets do so as a way to signal their support, without negatively impacts on their economic or energy interests. In this sense, the treatment of LULUCF (and more broadly, carbon sinks) could provide a pragmatic policy solution for countries to signal their ambition with little economic commitment.

Much of these findings generate more broader and larger questions, such as do the policies used by states reflect a forest transition (e.g. national circumstances) or do they reflect national ambition and the desire for political leadership as a climate leader? While my research does not answer these questions, it provides the necessary insight into linking the two disciplines together and brings new light into how they both might be used.

5.4. Relevance of findings

The results of this analysis are relevant in two broad ways. Firstly, from a theoretical perspective, there have been very few studies that assess all available NDCs for their LULUCF targets. The data I have collected about countries mitigation targets and the application of accounting rules (see Table 13) can be used to disentangle LULUCF emissions (non-energy emissions) from energy emissions – this is a vital step in reducing the uncertainty associated with estimating the long term impact of NDCs. In addition, the use of

the forest transition theory provides useful direction although not all aspects of the theory was tested in this analysis.

From a practical perspective, many of the insights from this analysis relate to on-going issues and discussions in the UNFCCC negotiations related to the development of the post-2020 accounting framework for land use and the global stocktake. Although NDCs were grouped according to how countries included the LULUCF sector, there was substantial variation in the approaches used by countries, and how information was reported in supporting documents and the information provided on the LULUCF sector differed substantially. Furthermore, the results of this analysis reveal insights into the state of monitoring, reporting and verification of GHG emissions and removals (a keystone of the Paris Agreement). The lack of information or methodologies for estimating emissions and removals from the LULUCF sector from some key developing countries underlines the need for greater capacity and support in the future for reporting and accounting. This insight supports the literature on LULUCF in NDCs and highlights the need for greater transparency.

5.5. Link to ambition

One of reasons to assess the national circumstances of a country's NDC is to gain insight into a country's climate change ambition. While I have not assessed ambition directly, the ambition of countries NDCs and their LULUCF target underpins this analysis. As pointed out in the literature, LULUCF is closely linked to ambition and effort sharing. LULUCF measures can be used to an extent to offset lack of action to reduce GHG from other sectors. While some NDC assessments do not include the LULUCF sector (Climate Action Tracker: 2010), given the prominence of the sector, the ambition of LULUCF policies and targets can impact the overall ambition of NDCs. One possible way to explore the relationship between ambition and LULUCF components is to take my grouping and apply an NDC ambition index (T. Kuramochi 2015; Swingle 2016; Northrop and Waskow 2015; Höhne et al. 2018). This may provide specific groupings of countries dependant on the level of LULUCF ambition and the level of overall NDC ambition.

The second element of ambition relates to the integrity and transparency of accounting rules. The LULUCF accounting rules have been historically the site of contention will be another arena where countries address ambition. Countries who have forestry resources will use them to help meet climate mitigation targets. While theoretically, the use of LULUCF activities in a countries target means there is greater opportunity for countries to take bolder policy choices related to energy, and rely on LULUCF as a backup, one can infer that

countries may also use LULUCF to avoid making expensive decisions. More analysis is required to support this statement.

5.6. Other reflections

One feature of analysing NDCs was the synergy between mitigation and adaptation options. While adaptation is not included in the scope of this analysis, its prominence in NDCs suggests that while LULUCF activities may be excluded from mitigation targets, countries will continue to engage in sustainable forest management the LULUCF activities without being formally admitted to do so.

Further analysis is required to assess the relationship between LULUCF and non-energy policies and the configuration of a countries energy profile. This is especially relevant for countries with relatively large LULUCF emissions, but will be overtaken by energy or industrial emissions in the future (Cox, Royston, and Selby 2016). For example, it is estimated that by 2030, 50% of Indonesia's GHG emissions are projected to come the energy sectors, and LULUCF emission will contribute only 37%. Wijaya et al. has briefly alluded to the potential impact of Indonesia increasing palm oil production, but did not provide further analysis (2017). While there are many more relevant factors in assessing national circumstances and capabilities, I did not have time to assess them all. These include the strength of institutions or political regime which require further research to explore their role.

The NDCs in this analysis represent the first submissions by Parties' to the Paris Agreement and are the first time Parties' have established and communicated mitigation targets. Given that the a) the Paris Agreement requires that all Parties to submit new or revised NDCs every five years which demonstrate enhanced ambition, and b) the post-2020 LULUCF accounting system is undeveloped, we can expect subsequent NDCs to clarify ambiguity or reflect the advancements within the negotiations about accounting for emission and removals from LULUCF. As many NDCs alluded to the need for greater capacity in relation to reporting (specifically, monitoring, reporting and verification) of emissions, we can expect that subsequent NDCs will have more clarity and include the sufficient information needed to estimate emission and removals from the LULUCF sector. A comparison between the first and subsequent or 'second' NDCs using this methodology could provide additional insights into how national countries ambition changes over time or if bold policy choices reflect increased ambition or shifting national circumstances.

6. Conclusion and recommendations

This research provides general insights into how countries have organized their LULUCF commitments, based on theoretical approaches from the forest transition literature and comparative environmental politics. These theories provide a useful starting point to unpack the national circumstance and capabilities that may determine countries mitigation targets. From these theories, we can expect countries to treat the LULUCF sector within their NDCs according to their stage in forest transitions, and more broadly, along their national socio-economic structures. From assessing NDCs and categorizing them based on their treatment of the LULUCF sector, the hypotheses outline above generally hold. However, I have only made generalizations based on my assessment and further analysis to test other relevant factors in forest transition is required. Insights into the national circumstances, which drive countries mitigation targets, may be used to gauge the level of ambition that countries take and also the feasibility of mitigation targets

Considering the number of NDCs that include or partially include the LULUCF sector, it is clear that LULUCF remains an important sector for climate mitigation. As countries undergo forest transitions and economic development, carbon sinks may act as a suitable bridging option for climate mitigation. The importance of LULUCF is only expected to increase over time as more countries refine their NDCs and strive to take more ambitious actions. This also places greater focus on the transparency and integrity of the land-sector accounting system to ensure that emissions and reductions from LULUCF are fairly and accurately estimated, measured and projected. The importance of transparency in reporting and accounting is another key insight from this research. While NDCs were grouped according to how they included the LULUCF sector, there were significant variations in the level of information provided and approaches used to estimate LULUCF emissions.

Further analysis is required assessing national circumstances and capabilities, as I did not have time to test them all. These include the strength of institutions or political regime. In particular it would be useful to assess the relationship between LULUCF and non-energy policies and the configuration of a countries energy profile. This is especially relevant for countries with relatively large LULUCF emissions, but will be overtaken by energy or industrial emissions in the future (Cox, Royston, and Selby 2016). Such analysis could test the hypothesis earlier from comparative environmental politics about whether a countries

support for carbon sinks is based on a political normative symbol or whether it is related to the national circumstances, such as the size of its economy.

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8. Appendixes

8.1. NDC summary of top ten global emitters and LULUCF commitment

	Name	NDC Summary	Total GHG Emissions Excluding LUCF (MtCO2e)	Total GHG Emissions Including LUCF ($MtCO_2e$)	% of global emissions	Land-Use Change and Forestry (MtCO2)	Grouping
1	**China**	Peaking of C02 around 2030 and making best efforts to peak early; lower carbon dioxide emissions per unit of GDP from 2005 level; increase the share of non-fossil fuels in primary energy consumption to around 20% and specific land related target: To increase the forest stock volume by around 4.5 billion cubic meters on the 2005	10975,5	10684,29	22,44667117	-291,21	Group 1a
2	**United States**	The United States intends to achieve an economy-wide target of reducing its greenhouse gas emissions by 26%-28% below its 2005 level in 2025 and to make best efforts to reduce its emissions by 28%.	6235,1	5822,87	12,23329282	-412,23	Group 1b
3	**EU28 Member States**	At least 40% domestic reduction in greenhouse gas emissions by 2030 compared to 1990, to be fulfilled jointly, as set out in the conclusions by the European Council of October 2014.	4399,15	4122,64	8,661272245	-276,51	Group 2
4	**India**	Policies and actions, sp 5. To create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030.	3013,77	2887,08	6,065478885	-126,69	Group 1a
5	**Russia**	Limiting anthropogenic 6greenhouse gases in7 Russia to 70-758% of 1990 levels by the year 2030 might be a long-term indicator, subject to the maximum	2322,22	2254,47	4,736425794	-67,74	Group 1b

		possible account of absorbing capacity of forests.					
6	**Indonesia**	committed to reduce unconditionally 26% of its greenhouse gases against the business as usual scenario by the year 2020."; condition target of 29%	760,81	1981	4,161891486	1220,20	Group 1a
7	**Brazil**	Brazil intends to commit to reduce greenhouse gas emissions by 37% below 2005 levels in 2025.	1012,55	1823,15	3,830263737	810,59	Group 1a
8	**Japan**	Reduction of 26.0% by fiscal year (FY) 2030 compared to FY 2013 (25.4% reduction compared to FY 2005) (approximately 1.042 billion t-CO2 eq. as 2030 emissions). LULUCF included and removals accounted for using KP rules	1344,58	1207,3	2,536421803	-137,28	Group 1a
9	**Canada**	Economy-wide target to reduce its greenhouse gas emissions by 30% below 2005 levels by 2030.". To achieve this target, Canada must reduce its total economy-wide emissions to 523 Mt in 2030."	714,12	856,28	1,798962363	142,16	Group 1b
10	**Mexico**	Reduce unconditionally 25% of its Greenhouse Gases and Short Lived Climate Pollutants emissions (below BAU) for the year 2030. This commitment implies a reduction of 22% of GHG and a reduction of 51% of Black Carbon.	723,85	748,91	1,573388265	25,06	Group 1b

8.2. Significant countries with conditional NDC targets

Country	Mitigation target	Conditionality	Specific LULUCF target	Global GHG ranking
India	Policies and actions, specifically to create an additional carbon sink of 2.5	Conditional	Yes	4

	to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.			
Indonesia	Unconditional GHG target to reduce 26% of GHG against the BAU scenario by the year 2020; and conditional target of 29%	Both unconditional and conditional	No	6
Mexico	Unconditional GHG target to reduce 25% of GHG below BAU for 2030	Both unconditional and conditional	No	10
Nigeria	Unconditional GHG target to reduce 20% below BAU. Unconditional and conditional targets in energy	Both unconditional and conditional	No	15
South Africa	Trajectory target of emissions in a range between 398 and 614 Mt CO_2–eq, as defined in national policy by 2025 and 2030	Partially conditional	No	16
Malaysia	Reduce GHG emissions intensity of GDP by 45% by 2030 relative to the emissions intensity of GDP in 2005: 35% is on an unconditional basis; and 10% is conditional upon climate finance, technology transfer and capacity building	Both unconditional and conditional	No	17

Table 18 Top ten countries by reported forest area in 2015. Source (FAO 2016)**.**

Country	**Annual forest area net loss**	
	Area (thousand ha)	Rate (%)
Brazil	984	0.2
Indonesia	684	0.7
Myanmar	546	1.8
Nigeria	410	5.0
United Republic of Tanzania	372	0.8
Paraguay	325	2.0
Zimbabwe	312	2.1
Democratic Republic of	311	0.2

the Congo		
Argentina	297	1.1
Bolivia	289	0.5

Table 19 Top ten countries reporting the greatest annual net loss of forest area, 2010-2015. Source: (FAO 2016)

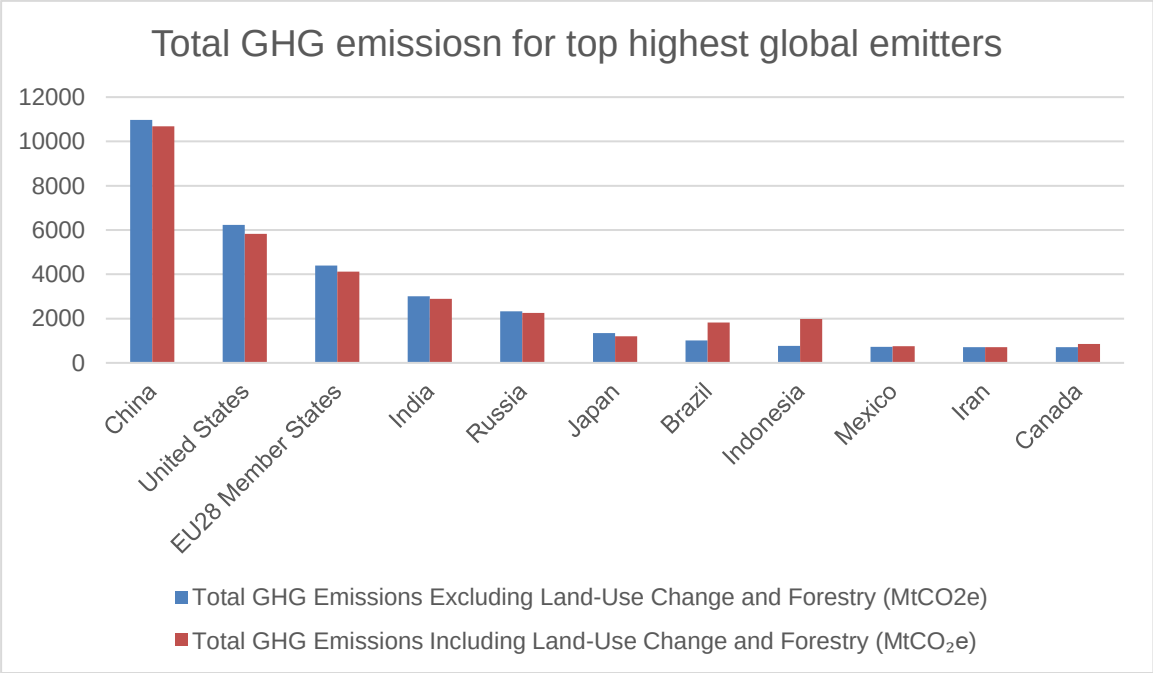
Country	**Annual forest area net gain**	
	Area (thousand ha)	Rate (%)
China	1 542	0.8
Australia	308	0.2
Chile	301	1.8
United States of America	275	0.1
Philippines	240	3.3
Gabon	200	0.9
Lao People's Democratic Republic	189	1.0
India	178	0.3
Viet Nam	129	0.9
France	113	0.7

8.3. Significant global GHG emitting countries

	Country	**Region**	**Total GHG Emissions Excluding LUCF (MtCO2e)**	**Total GHG Emissions Including LUCF ($MtCO_2e$)**	**% of global GHG emissions**
1	China	Asia	10975,5	10684,29	22,44667117
2	United States	Northern America	6235,1	5822,87	12,23329282
3	EU28 Member States	Europe	4399,15	4122,64	8,661272245
4	India	Asia	3013,77	2887,08	6,065478885
5	Russia	Europe	2322,22	2254,47	4,736425794
6	Indonesia	Asia	760,81	1981	4,161891486

7	Brazil	Latin America and the Caribbean	1012,55	1823,15	3,830263737
8	Japan	Asia	1344,58	1207,3	2,536421803
9	Canada	Northern America	714,12	856,28	1,798962363
10	Mexico	Latin America and the Caribbean	723,85	748,91	1,573388265
11	Iran	G-77 and China	714,96	711,88	1,495591777

8.4. High emitters



8.5. Emissions versus forest area. Source: (WRI et al. 2015)

Country	Rank by Forest Area (2015)	Rank in Total Annual Emissions (2012)
Russia	1	4
Brazil	2	6

Canada	3	8
United States	4	2
China	5	1
Democratic Republic of Congo	6	37
Australia	7	12
Indonesia	8	5
Peru	9	46
India	10	3

Country	**Global GHG emissions**	**LULUCF in NDC**	**Emissions profile**	**Forest cover**
China				
India				
Indonesia				
Brazil				
Japan				
Democratic Republic of Congo				

Country	Total GHG Emissions Excluding Land-Use Change and Forestry (MtCO2e)	Total GHG Emissions Including Land-Use Change and Forestry ($MtCO_2e$)	% of global emissions	Ranking of global GHG emissions	Land-Use Change and Forestry (MtCO2)
United States	6235.1	5822.87	12.23	2	-412.23
European Union (28)	4399.15	4122.64	8.66	3	-276.51

Brazil	1012.55	1823.15	3.83	7	810.59
Japan	1344.58	1207.3	2.54	8	-137.28
Canada	714.12	856.28	1.80	9	142.16
Australia	648.23	685.05	1.44	12	36.82
Turkey	419.7	390.86	0.82	20	-28.84
Ukraine	390.33	366.31	0.77	22	-24.02
New Zealand	76.59	58.47	0.12	63	-18.12
Sweden	50.75	48.07	0.10	69	-22.44
Norway	48.33	24.1	0.05	93	-24.23
Moldova	11.72	10.88	0.02	108	-0.8