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Are REDD+ countries gaming with their reference levels?

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Preface

This master's thesis marks the end of the master's degree program in economics at NMBU.

Initially I did not have any preferences for what topic to research for this thesis. The first topic I began researching this semester had to do with cost-benefit analysis. After a lot of thinking I decided to not go that route and instead ask my supervisor Arild Angelsen if he had any suggestions for me. He suggested looking into gaming in the REDD+ program, and I do not regret the decision of going with his suggestion.

I want to thank Arild for being my supervisor on this thesis. Thank you for all the help, insight, comments, and *Fantasy Premiere League* tips (even though they were never followed).

Lastly, I want to thank my fiancé, family and friends for the support and encouragement during this last semester.

Fredrikstad 14.05.22

Abstract (English)

The reference level is key element of the REDD+ mechanism and serves as a benchmark of which future emission reduction efforts are measured against, with the possibility of fiscal rewards if the mitigation efforts prove successful. Countries participating in the REDD+ program have a high level of autonomy and follow vague guidelines when submitting their reference level to the UNFCCC. This creates large incentives for countries to take advantage of this system by creating the highest possible reference level thus getting bigger rewards for the same mitigation efforts. Using deforestation data combined with data from the REDD+ country submissions, I investigate whether "gaming" behavior is present in three areas: the choice of reference period length, the use of the trend extrapolation method and in the adjustment for national circumstances. The results of this analysis show that there is not much evidence of gaming behavior in the choice of reference period length. The results from investigating the countries using trend extrapolation certainly show what looks like gaming behavior as all countries benefit from using this method. The same goes for the countries which adjusts for national circumstances where most countries, but one, adjusts their FREL/FRL upwards.

Abstrakt (Norsk)

«Reference Level», eller referansenivået, er en viktig del av REDD+ mekanismen og fungerer som et benchmark som fremtidige reduksjoner i klimautslippsnivå måles opp imot, med muligheten for økonomisk gevinst om utslippsreduksjonene er suksessfulle. Land som deltar i REDD+ programmet har en høy grad av autonomi og følger vage rettningslinjer når de skal sende inn sitt referansenivå til UNFCCC. Dette skaper store insentiver for land til å utnytte dette systemet ved å skaffe seg et så høyt refereansenivå som mulig da dette kan gi større økonomisk gevinst for samme utslippsreduksjoner. Ved å bruke avskogingsdata fra kombinert med data fra de innsendte refereransenivåene undersøker jeg om det finnes tilfeller av land som utnytter systemet på tre forskjellige områder: lengden på referanseperiode, blant landene som benytter seg av trendekstrapoleringsmetoden, og blant landene som justerer referansenivået for «nasjonale omstendigheter». Resultatene fra denne analysen viser at det ikke er noe tilstrekkelig beviser for utnyttelse av systemet ved valg av lengde på referanseperioden. Blant de trendekstrapolerende landene så ser det mer ut som det er stor utnyttelse av systemet da alle landene tjener på å benytte seg av denne metoden i form av et høyere referansenivå i motsetning til å bruke den mer vanlige historisk gjennomsnitt-metoden. Det samme gjelder for landene som justerer for nasjonale omstendigheter der alle bortsett fra et land justerer referansenivået sitt opp.

Overview of figures

Overview of tables

Contents

1 Introduction

Reducing Emissions from Deforestation and Forest Degradation, or REDD+ for short, is a framework within the United Nations Convention on Climate Change (UNFCCC). This framework, as the name alludes to, is designed to reduce emissions from deforestation and forest degradation and to help countries with the sustainable management of forests as well as the conservation and enhancement the forest carbon stock in developing countries. REDD+ was developed through the various COP climate negotiations since 2005.

The REDD+ mechanism works such that participating countries submit their reference emission level from forest related activities to the UNFCCC for a technical assessment. This emission level is called the *"reference level"* and serves as the benchmark of which future mitigation efforts are compared to. There are at least two more common methods of constructing the reference level. The first is the most common which is the historical average method. In this method a country takes the total emissions over a reference period, usually 10 or 15 years, and calculate the annual average emissions, which serves as the reference level. The second method is the trend extrapolation method where countries chose a reference period and calculates the trend in emission for said period. The trend is then used to calculate future emissions which serves as the reference level. On the top of this countries can adjust their reference level for national circumstances which is a practice with vague guidelines and usually ends up being upwards adjustments.

One of the goals of the REDD+ framework is that it will be used as a payment-based system. If a country manages to reduce its emission to a lower level than the benchmark in the coming years, they can receive payments for their efforts. The larger reduction in emission the bigger the reward. This is where a problem occurs. The UNFCCC guidelines for REDD+ are vague and thus they can be taken advantage of. There are no standard or mandatory method of calculating the reference level. There is an incentive to "game" the system by being selective in the choice of method to create the highest reference level possible as the rewards will be greater for the same mitigation efforts in the future. The presence of "gaming" in the submission by the REDD+ countries is what this analysis will investigate. The possible consequence of gaming is that countries get overpaid for their mitigation efforts.

The research question of this thesis is:

> *Are REDD+ countries "gaming" the system by being selective with the choice of numbers and methods in their reference level setting?*

This analysis will investigate three different areas of which gaming might occur by reviewing the country reference level submissions. The first area is in the length of the reference period, the second is by using the trend extrapolation method or not, and the third by adjust the reference level upward due to “national circumstances”.

The thesis in structured as follows: it starts with section 2 the background chapter which reviews the scope of the world’s forests followed by an overview of deforestation and its environmental impact. The last part of section 2 contains the history of REDD+ and its components such as the five REDD+ activities and the reference level. Section 3 is the theoretical part and contains the theory on the construction of the reference level as well as the potential for biases and gaming within the REDD+ framework. Section 4 describes the data and the methodology used to investigate “gaming” as well as specifying a hypothesis for each of the three areas of REDD+ mechanism which is being investigated. The results and discussion are presented in section 5. The concluding remarks are presented in section 6.

2 Background

This section begins with a short presentation of the importance of the world's forests in 2.1 and its environmental impact in 2.2. Then part 2.3 will lay out the problem and scope of deforestation. Part 2.4 presents the REDD+ program with its history and components.

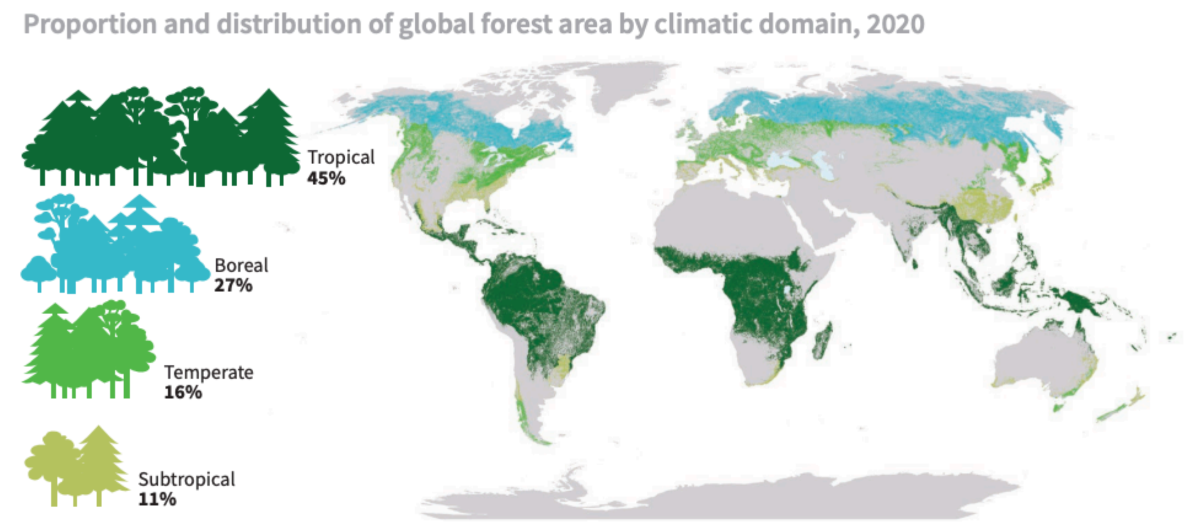
2.1 Importance of Forests

Forests play an integral part in the planets' ecosystem. Are we to reach our climate targets, the protection and sustainable management of forests needs to be part of the effort. The 15th goal of the *United Nations Sustainable Development Goals* is stating:

> *"Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt the reverse land degradation and halt biodiversity loss."* UN (2022)

According to a report by FAO (2020a), 31 % of the total land area of the planet is covered by forests, which is about 40.6 million km^2. The world's forests are found in four climate domains: tropical, subtropical, boreal and temperate. The largest group is tropical forests which makes up about 45 percent of the total forest. Figure 1 below is an illustration from the FAO report which shows the distribution of forests in the four climate domains.

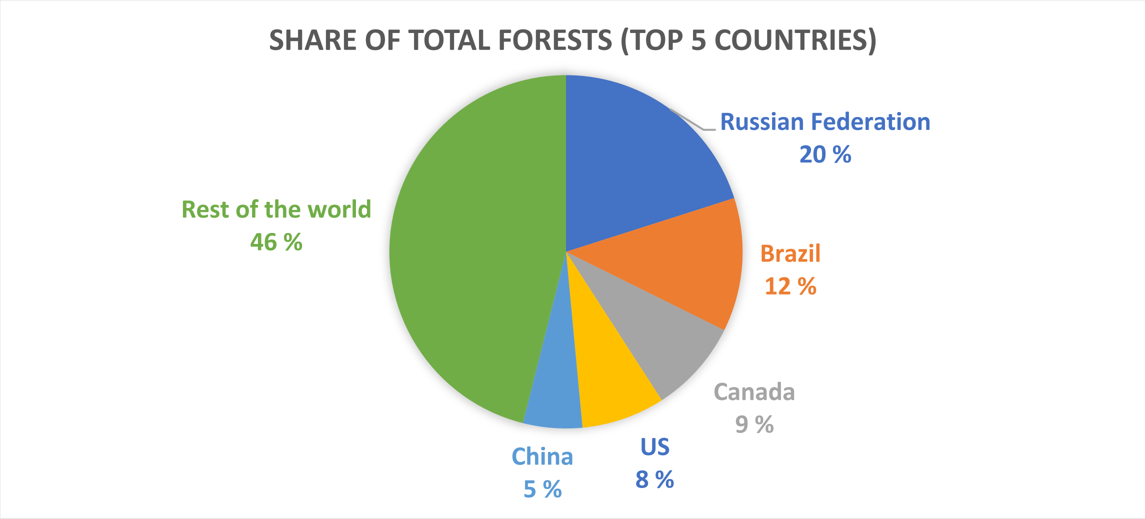
Figure 1: Distribution of forest by climate domain, figure from report



Source: (FAO 2020, p 1)

The forests of the world are not distributed equally. Five countries (Russia, Brazil, Canada, the US and China) have 54 percent of all forests in the world as seen in Figure 2 below:

Figure 2: Share of total forest area



Source: (FAO 2020, p 11)

Forests provide habitat for a large number of animals and plants. In their *"The State of the World's Forests 2020"* report FAO (2020d) describes the scope of biodiversity within the world's forests:

> *"Forests harbour most of Earth's terrestrial biodiversity. The conservation of the world's biodiversity is thus utterly dependent on the way in which we interact with and use the world's forests. Forests provide habitats for 80 percent of amphibian species, 75 percent of bird species and 68 percent of mammal species. About 60 percent of all vascular plants are found in tropical forests." (FAO, 2020d)*

In addition to being vital to the world's ecosystem and biodiversity, the world's forests provide the employment for an estimate 86 million people (FAO, 2020d). The accounting of the direct, indirect and induced employment within the formal forest sector makes up about 46 million out of the 86 million jobs. The remaining 41 million jobs are estimated from the informal forest sector, which is described as the *"non-commercial, subsistence or unregulated and un-reported small-scale enterprises"*.

2.2 Deforestation

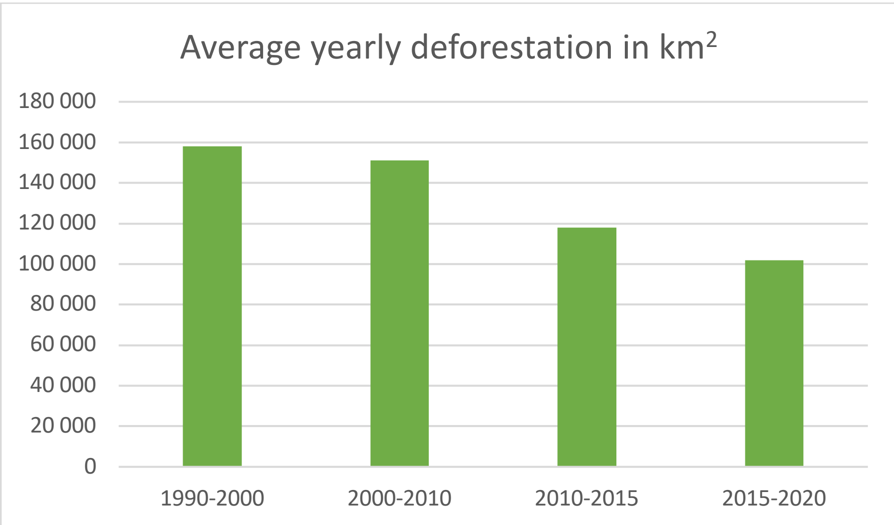
FAO provides the following definition of deforestation in their 2020 report key findings:

> *"FAO defines deforestation as the conversion of forest to other land uses (regardless of whether it is human-induced). "Deforestation" and "forest area net change" are not the same: the latter is the sum of all forest losses (deforestation) and all forest gains (forest expansion) in a given period. Net change, therefore, can be positive or negative, depending on whether gains exceed losses, or vice versa". (FAO, 2020b, p. 2)*

Between 1990 and 2020, about 1.78 million km^2 of the worlds forest area has been lost (FAO, 2020a). However, there has been a reduction in the average yearly net forest loss since 1990. In the first ten-year interval between 1990 to 2000 the global annual forest area net change was at -7.8 percent. Then between 2000 and 2010 the number was at -5.2 %. It further declined to -4.7% between 2010-2020. FAO attribute the reduction in the global forest area change to decreased deforestation levels in some countries as well as increased afforestation and natural forest expansion in others.

Looking at deforestation alone, FAO reports that since 1990, 4.2 million km^2 of forest has been lost because of deforestation. There has been a decline in the global deforestation rate since 1990. The deforestation rate between 1990-2000 was 158 000 km^2 per year, whereas the deforestation rate between 2015-2020 was 102 000 km^2 per year. Figure 3 shows the decline in deforestation rate:

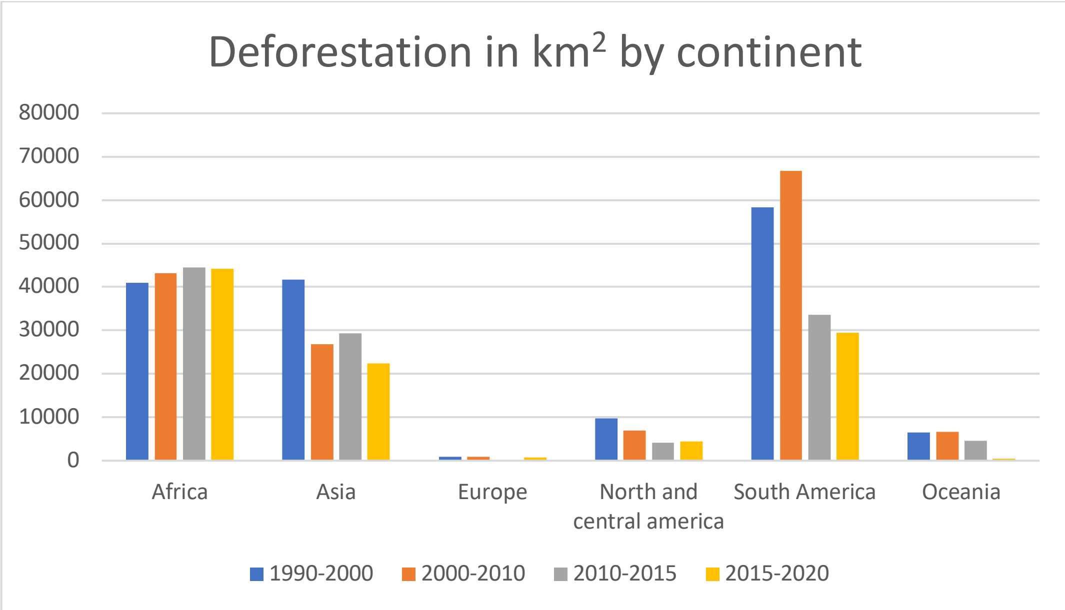
Figure 3: Average yearly deforestation in km2



Source: (FAO 2020, p 19)

South America had the largest annual average deforestation rate in the 1990s with 58 370 km^2. Since then, the annual average deforestation has reduced to 29 530 km^2 in 2015-2020. Europe, North- and Central America as well as Oceania all have a smaller deforestation rate compared to the 1990s. Africa which was in 3rd place in the 1990s with 40 960 km^2 is today the leading continent with an annual average deforestation rate of 44 140 km^2. Africa is the only continent with higher deforestation today compared to the 1990s. Figure 4 shows the annual average deforestation rates of each continent for each of the four interval periods.

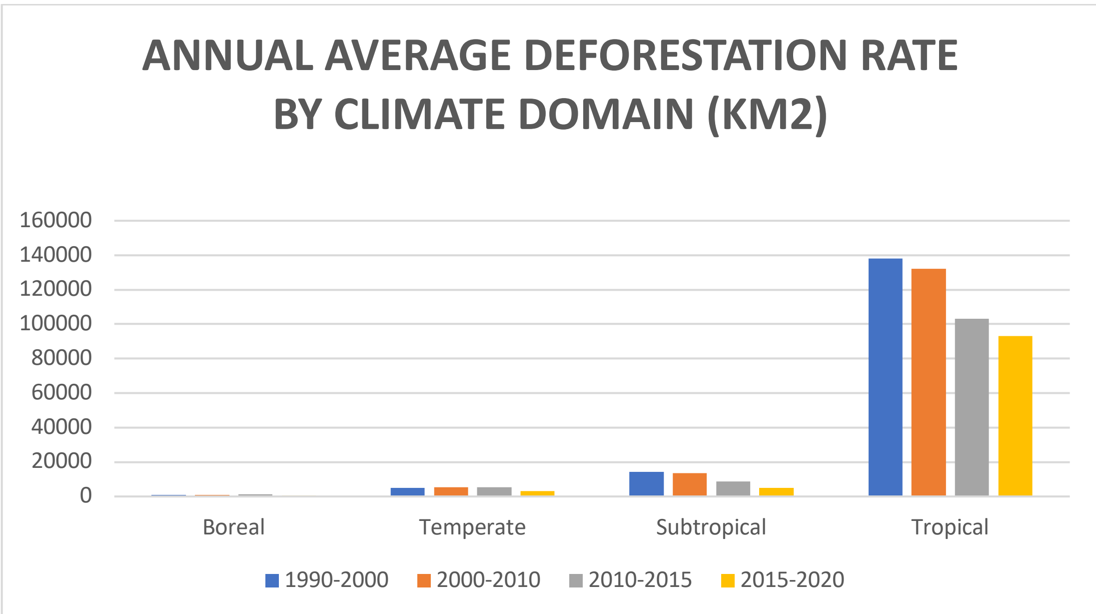
Figure 4: Deforestation in km2 by continent



Source: (FAO 2020, p 19)

A majority of the total forest loss from deforestation are located in the tropical domain. Since 1990 the share of total deforestation in the tropical domain has stayed above 86% and in the last interval, from 2015-2020, the share of total deforestation in the tropical domain is at about 91% which is the largest share so far. Figure 5 show the average annual deforestation in km^2 by climate domain.

Figure 5: Annual Average Deforestation in km2 by climate domain



Source: (FAO 2020, p19)

Prof. Matthew Hansen which is one of the world's leading experts on forests and remote sensing describes the worlds forest as “climate regulators on a global scale” (BBC, 2021). The worlds forest is found to absorb a net estimate of 7 600 mtCO_2 per year (Harris et al., 2021). According to IPCC (2021) tropical deforestation accounts for 14% of global greenhouse gas emission. The preservations of forests as a mitigation effort could contribute significantly to global emission reductions. Griscom et al. (2017) outline 20 *“natural climate solutions”,* and the preservation of tropical forests is among the most significant. According to their findings, NCS can provide about a third of the cost-effective mitigate needed until 2030 to stabilize the climate below 2 degrees warming.

2.3 REDD+

2.3.1 The History of REDD+

The United Nations Framework Convention on Climate Change (UNFCCC) describes REDD+ (Reducing Emissions from Deforestation and Forest Degradation) as:

> *“a framework created by the UNFCCC Conference of the Parties (COP) to guide activities in the forest sector that reduces emissions from deforestation and forest degradation, as well as the sustainable management of forests and the conservation and enhancement of forest carbon stocks in developing countries.” (UNFCCC, 2022b)*

The development of the REDD+ framework started at the COP 11 conference in Montreal in 2005. Papua New Guinea and Costa Rica, on behalf of The Coalition for Rainforest Nations, wanted to start a discussion at the UNFCCC to introduce emission reduction from deforestation and forest degradation as a mitigation measure. They submitted the document *Reducing emissions from deforestation in developing countries: approaches to stimulate action,* where they addressed their concerns about the tropical deforestation and forest degradation, and that they wanted a UNFCCC financing mechanism for reducing emission from these activities:

> *“What the parties are asked to consider, in effect, is how the UNFCCC can be used better to draw developing nations towards emissions reductions by functioning as a mechanism to finance environmental sustainability – while completely fulfilling its climate objectives. Properly harnessed, the carbon emission markets can monetize environmental resources and capitalize sustainable development.”(Government of Papua New Guinea, 2005, p. 9)*

In 2007 at COP13 , "The Bali Action Plan", the decision 1/CP13 and 2/CP.13 (UNFCCC, 2007) acknowledge that deforestation and forest degradation lead to emission. Decision2/CP13 §2 encourages all parties that can to help developing countries develop better forest monitoring capabilities. §3 encourages parties to take measures to reducing emission from deforestation and forest degradation and enhance the forest carbon stock through sustainable management of forests by addressing the drivers of deforestation which is relevant to their national circumstances. Further in the Bali decision, the five REDD+ activities were presented:

a. Reducing emissions from deforestation
b. Reducing emissions from forest degradation
c. Conservation of forest carbon stocks
d. Sustainable management of forests
e. Enhancement of carbon stocks

The basic idea of the REDD+ mechanism is that countries calculate their emission from these forest related activities and report them to the UNFCCC. The calculated emissions are called the "reference level" or "forest reference emissions level", FREL for short.

The next development for REDD+ happened in Copenhagen in 2009 at COP 15 Decision 4/CP.15 §7 states that countries should consider historical data and adjust for national circumstances when constructing the FREL (UNFCCC, 2009).

The Cancun Agreements from 2010 Decision 11/CP.16, §71 (2010) lay out the four requirements for participating in the REDD+ program. These are related to forest reference levels, a national REDD+ strategy or action plan, safeguards, and Monitoring, reporting, and verifying systems (MRV systems).

The Durban decisions in 2011 at COP 17 gave further guidance on the development of reference levels (UNFCCC, 2011). FRELs should be used as benchmark to assess party countries performance in implementing the five REDD+ activities. Decision 12/CP.17 §9 states that countries which adjusts for "national circumstances" should include details on how the national circumstances were considered such as methodological information, description of datasets, description of relevant policies and plans, etc. The noteworthy takeaway here is that the decision does not state what type of national circumstances are to be included, leaving each country to decide which factors are relevant. §10 recognizes the stepwise approach proposed detailed in Herold and Angelsen (2012). The stepwise approach is a roadmap to better forest monitoring capabilities. It takes into account that different countries have different capacity and data availability and therefore sets out a path for countries to follow so that they can incorporate better data and methods as they develop. §11 states that countries are allowed to start out with a sub-national FREL if data availability and capacity on the national scale are not yet developed or sufficient. The end goal however is to transition into national scale FREL. §12 states that the FREL should be updated periodically as new knowledge and new trends become apparent. Finally, §15 states that the UNFCCC should start working on the process of technical assessments of FRELs.

The Warsaw Framework for REDD+, that was agreed upon in 2013 at COP 19, introduced the process of a technical assessment of the country FREL submissions (UNFCCC, 2013). Decision 13/CP.19 §1 states that each country FREL submission shall be subjected to a technical assessment and §2 states that the proposed FREL is to be assessed in the context of result-based payments. Further, decision 9/CP.19 reaffirms that payments as part of a result-based payment system can come from various sources. It also encourages financial entities and institutions to provide predicable and fairly distributed payments and to expect the number of receiving countries to be increasing. Decision 15/CP.19 §3 encourages parties involved to reduce the drivers of deforestation and forest degradation.

2.3.2 REDD+ Activities

There are five REDD+ activities which countries are encouraged to implement in their submission of the forest reference emission level. These were first presented in the Bali Action Plan decision 2. There are no official definitions for these five activities from the UNFCCC. According to the UN-REDD program academy (2016), an implementing UN body to be distinguished from the UNFCCC, this is to allow for flexible implementation for developing countries as well as providing room for national interpretations of the REDD+ activities. Even though there are no official definition for activities, the UN-REDD Program provides general explanations and examples which are presented below:

Table 1: REDD? Activity descriptions

REDD+ activity	**Description**
Reducing emissions from deforestation	*"Deforestation is the direct human-induced conversion of forest land to non-forest land."*
Reducing emissions from forest degradation	*"Degradation is the human induced loss of carbon stocks within forest land that remains forest land."*
Conservation of forest carbon stocks	*"Refers to any effort to conserve forest"*
Sustainable management of forests	*"Generally refers to bringing the rate of extraction in line with the rate of natural growth or increment to ensure near zero net emissions."*
Enhancement of forest carbon stocks	*"Refers to (1) non-forest land becoming forest land and (2) the enhancement of forest carbon stocks in the forest land remaining land."*

Source: (UN-REDD, 2016, p. 13)

2.3.3 Forest reference (emission) level

Forest reference (emission) level, or FREL/FRL for short (sometimes only referred to as "reference level"), is the estimated emission levels in the absence of REDD+ policies. A forest reference emission level (FREL) includes only emission from deforestation and forest degradation, whereas a forest reference level (FRL) includes both emissions and removals (carbon stock increases) and can include all REDD+ activities. FRELs are part of the four requirements for participating in the REDD+ program which were agreed upon in The Cancun Agreements. In addition, The Warsaw framework for REDD+ requires participating countries to submit their FREL to the UNFCCC for a technical assessment.

The level of emission is calculated using two main components. The first is activity data, which is the level of change in forest cover area from the different REDD+ activities included measured in hectares or km^2. This is the estimated future activity data and can be calculated by using different methods. The second component is the carbon stock, which is the amount of greenhouse gases (GHG) contained in each area unit (per hectare or km^2). In this analysis I will be focusing on the guidelines and possibility of gaming in the activity data, not for the carbon stock.

The most common method of estimating the activity data in the country submissions is the historical average method where an annual average of deforestation is calculated based on a 10- or 15-year period. Then there is the trend extrapolation method where countries calculate an equation, usually a linear trend equation, that estimates the future emissions. On the top of this countries are able to adjust their reference level for national circumstances The historical average and trend extrapolation methods, as well as the adjustment for national circumstances will be explained in more detail later in this paper. There is also an alternative method of using simulation models to estimate future activity levels. This method has rarely, if not never, been used in the REDD+ submissions.

3 Theory

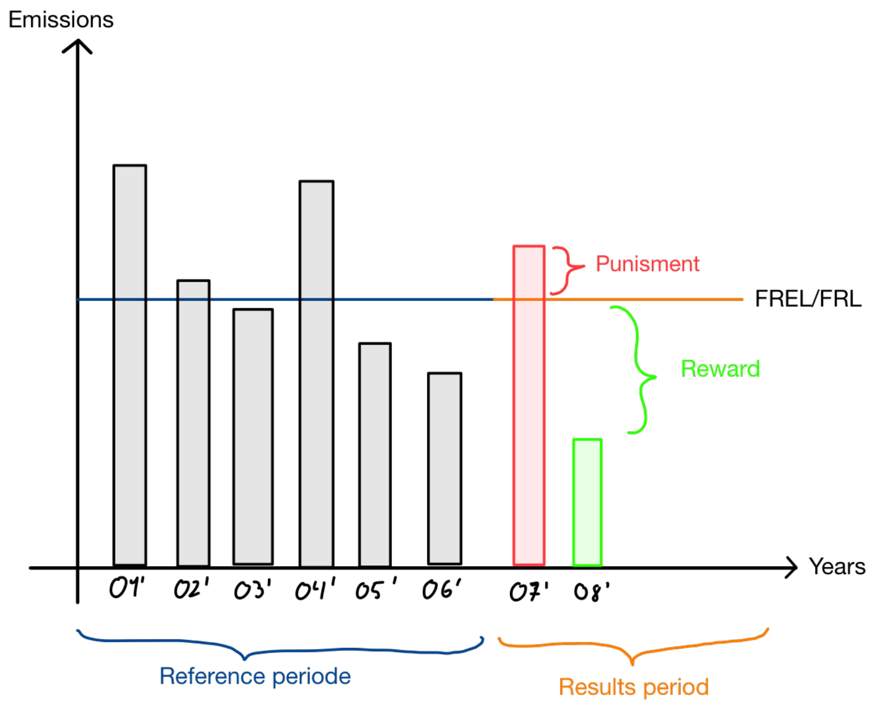
This section contains the theoretical component of the analysis. First part 3.1 describe the two different interpretations of what the FREL is. The next two sections go through the two main methods of constructing the FREL/FRL which is the historical average method in part 3.2 and the trend extrapolation method in part 3.3. Then in part 3.4 the mechanism of adjusting for national circumstances is presented. This section ends with part 3.5 where the potential for biases and gaming within the REDD+ mechanisms are laid out together with three hypothesis which are to be tested.

3.1 Business as usual vs Crediting Line

In terms of REDD+, the forest reference emission level can have two meanings. The first is FRELs as a benchmark for measuring the policy impacts of REDD+. This is called the *business-as-usual baseline* (BAU for short). This is the estimated future emission from deforestation and forest degradation in the absence of REDD+ policies.

The second meaning of FRELs are the *crediting baseline (CB)* or *compensation baseline,* which is used for result-based-payment. The crediting baseline is the benchmark in which countries' future mitigation efforts are compared to. The country is rewarded if future emissions are lower than the baseline, and receive no fiscal reward, maybe even punishment if emission are higher than baseline as shown in Figure 6. The blue line is the historical average emission and the orange line is the FREL.

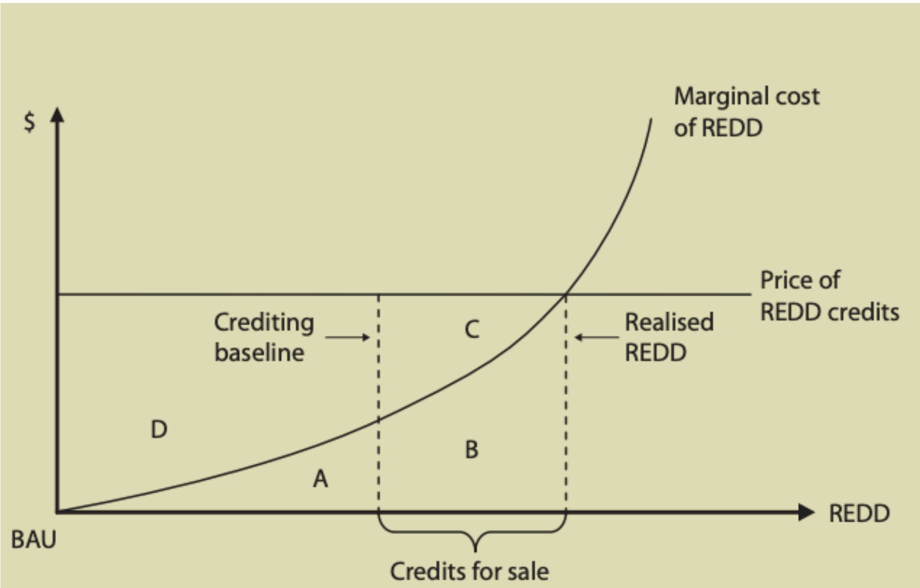
Figure 6: Reference level as crediting baseline



The country submissions make it clear that the FREL/FRL is submitted in order to participate in a result-based payment scheme and this use of the FREL/FRL is what this analysis will investigate. It also remains unclear if result-based systems will follow the proposed FRELs/FRLs or whether they will be subject for negotiations between the country and the funders or buyers of carbon credits.

There has been debated whether the BAU baseline and the crediting baseline should be at the same level. Angelsen (2008) argues that there is net benefit for REDD+ participating countries in the case where the crediting baseline is below the BAU baseline. In a result-based system where participating countries receive payments for preserving forest, the incentive for the participating countries is to reduce deforestation to the point where the marginal reduction cost of deforestation is equal to the market price of the credits. Figure 7 below show the marginal cost curve and the market price of REDD+ credits. The space between the price of REDD+ credits and the marginal cost or reducing deforestation is the net gain or "profit" participating countries receive. The figure show that with a tight crediting baseline, as long as area "C" is greater than area "A" then there is economic incentives to join REDD+. Therefore there is possible to use a tighter crediting baseline than what the BAU is thus reducing the costs of a payment-based system for REDD+.

Figure 7: «No-lose crediting baseline"



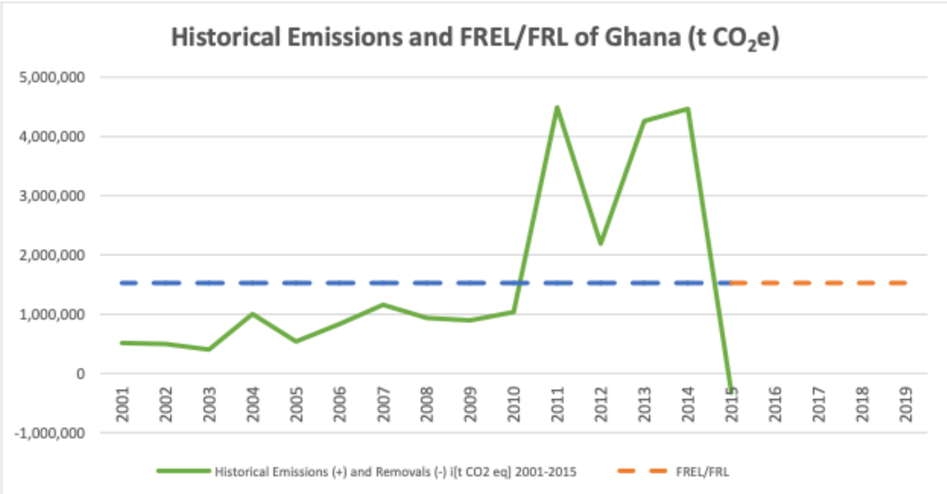
Source: Angelsen (2008, p. 59)

For the remainder of this analysis refer to the forest emission reference levels as FRELs/FRLs or just *"reference level"*.

3.2 Historical average

The suggestion from the Bali Action plan is that the baseline should be constructed using national historical deforestation rates. The national historical deforestation rate is usually the average of a 10-year period updated every 3-5 years. Figure 8 show from Ghana's FREL/FRL submission to the UNFCCC and the use of the historical average method. The blue line is the average emission during the reference period (2001-2015), the green line is the actual emission for each year, and the orange line is the FREL/FRL.

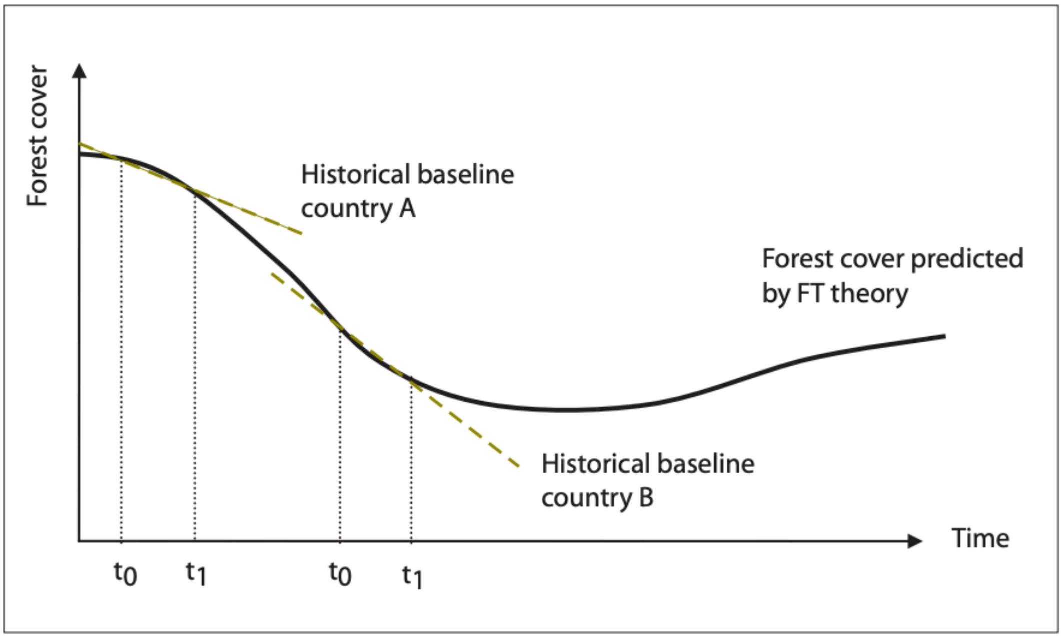
Figure 8: Ghana´s FREL/FRL using historical average, figure from submission



Source: Government of Ghana (2021, p. 28)

There are, however, some challenges by using historical averages to construct the baseline. One of the issues raised by Angelsen (2008) is that historical deforestation rates might be systematically under- or overestimate deforestation rates depending on a country´s development in the *Forest Transition (FT) Theory*. The forest transition theory (Mather, 1992) (Angelsen, 2007) states that a country in the early stages of economic development have historically had low rates of forest cover area change. Once the country develops economically, the forest area change rate accelerate due to increased deforestation and forest degradation. After further economic development, the forest cover area change rate stabilizes. Figure 9 show the different stages of the forest transition theory:

Figure 9: The Stages of the Forest Transition Theory



Source: Angelsen (2008, p. 56)

Country A in figure 9 is in the early FT stage would underestimate future deforestation rates by using historical national average as method for constructing the baseline. Country B which is in a more economically developed stage of the FT theory would be overestimating its future deforestation rates using the same method of constructing the baseline.

Another way of construction a reference level is by using an historical *global* average deforestation rate as the reference level. Countries construct a reference level based on country specific data, but if the country specific data quality is poor or not available, then using a global deforestation rate to construct the country reference level may be justifiable. Angelsen (2008) lists two critical assumptions when using global deforestation for individual country reference level:

1. *"First it is assumed that differences in rates of deforestation reflect the differences in policies, and countries should not be rewarded (punished) for bad (good) policies by getting higher (lower) baselines."*

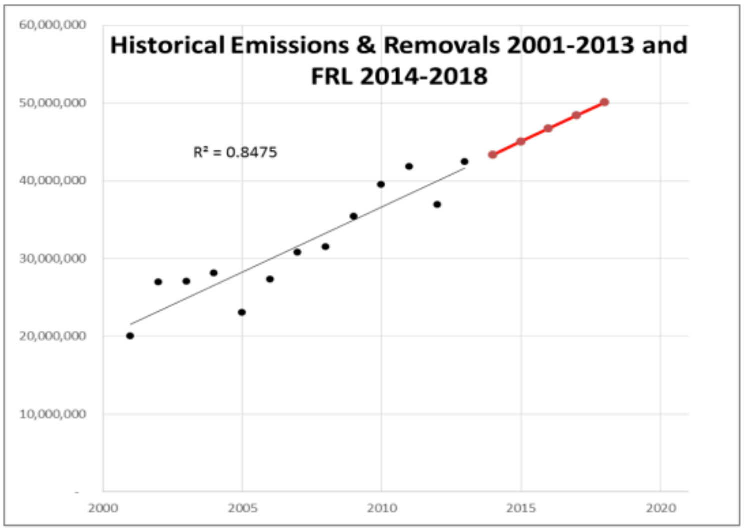
2. *"Second, the proposal assumes some global convergence in deforestation rates, and that over the long run all developing countries would deforest at the average global rate" (Angelsen, 2008, p. 57)*

Angelsen also presents objections to each of the two assumptions. Addressing the first assumption about deforestation rates being different due to policy differences, he states that countries which experience low deforestation rates to this because of economic development and forest scarcity rather than policy differences, according to Rudel et al. (2005). As to the second assumption about the convergence to a global average deforestation rate, the evidence is more in favor of the forest transition theory where each country goes through the different stages of deforestation rates rather than converging to a global average (Rudel et al., 2005) (Chomitz et al., 2007).

3.3 Trend extrapolation method

The trend extrapolation method is the use of a linear equation based on the trend in emissions and removals to predict the future reference level. This method gives the country a moving FREL/FRL over time, either increasing or decreasing unless there is not trend in the rates. An example of a country (Papua New Guinea) using the trend extrapolation method is shown below in figure 10.

Figure 10: Historical Emissions & Removals, & reference level for Papua New Guinea, figure from submission (2017)



Source: Government of Papua New Guinea (2017, p. 36)

Using the trend extrapolation method could be a useful method in the case of countries in the early stage of the forest transition theory. Developing countries that are in an early stage in the FT theory are expected to have increased economic development and thus increased deforestation. Using the trend extrapolation approach might help these countries to account for the future increase in deforestation in their FREL/FRL.

3.4 National Circumstances

The topic of national circumstances in the REDD+ setting is ambiguous due to the lack of clear guidelines. The UNFCCC Decision 4/CP.15 §7 states that countries should consider historical data and adjust for national circumstances when constructing their FREL/FRL. Further, Decision 12/CP.17 §9 states that countries which adjusts for "national circumstances" should include details on how the national circumstances were considered such as methodological information, description of datasets, description of relevant policies and plans, etc. There is no instruction on what these national circumstances are.

Proposals of methods on how to include national circumstances has been made and Angelsen (2008) lists a few:

The first is the method is to include a *development adjustment factor* (DAF). The idea is that developing countries will get a more generous baseline. He lists four justifications for this approach:

1. It could be justified by the fact that low GDP per capital countries are less developed thus in an earlier forest transition stage, thus is expected to have decreased levels of deforestation rather than continued low deforestation.
2. The second justification is that poorer countries have less capacity implement REDD and thus benefit from increased payments which can be invested in greater monitoring capabilities.
3. The UNFCCC has a principle of *"common but differentiated responsibilities"* which could be interpreted as poorer countries can have more relaxed or lower REDD requirements.
4. *"REDD should contribute to a transfer of resources to the very poorest countries (co-benefits)". (Angelsen, 2008, p. 56)*

The DAF is currently not a method which is being used nor discussed in the UNFCCC debates on adjustments for national circumstances.

Another approach to national circumstances is to include country specific factors in the formula for setting reference levels. These country specific factors could be population growth, population density, forest area, economic growth, the prices of commodities, location and governance variables.

The third proposal is by Motel et al. (2008) which suggest estimating government policies impact after the fact, after the crediting period, in order to reward countries for good, working, policies. Among the challenges with this approach is that there might be poor data availability in poor countries. This proposal has not made any footprint in the UNFCCC debates on national circumstances.

3.5 Potential Biases and gaming

The UNFCCC guidelines are vague to allow for flexibility in implantation. What this also opens up for is the possibility of "gaming" a result-based payment system. Where there is financial reward for self-reported results, there is always the risk of moral hazard. Letting countries submit their own reference levels could be compared to letting companies propose their own emission quotas. Climate agreements are outcomes of negotiations were everyone involved fights for their own interests and the agreed upon measures are voluntary. There is no world government that oversees and enforces the rules that are agreed upon. However, even though there is a possibility for gaming, this does not automatically mean that participating countries will take advantage of the vague guidelines and a system based on trust and reputation.

Politicians and leaders in their respective countries have two main incentives to take advantage of the system by adjusting their reference levels upwards. The first incentive is that an upwards adjustment will generate better results in emission reductions. As climate issues become more popular among voters, it is easy to imagine politicians in REDD+ participating countries would gain popularity by having better emission reduction results to show for, both domestically and at the global scene. The second incentive by upwards biasing the FREL is the payments for the same mitigation efforts would increase.

The definition of "gaming" used in this analysis is the same used by Angelsen (2018):

"*Gaming is the deliberate manipulation or choice of numbers for own benefit*"

Angelsen (2018) lists six reasons for why REDD+ reference levels might be particularly vulnerable to gaming. The first is differences in the level of payments in the "pay-for-results" system can be substantial depending on how the reference levels are set, which creates a significant economic interest in gaming. The second and third reasons are that the UNFCCC guidelines are vague, and the detailed rules are being written as the game is being played, and the political scope for critical assessment and evaluation of the submitted FRELs is limited. The fourth reason is that the empirical basis, the data, for how to estimate FRELs is for most countries thin, enlarging the scope for data selection and interpretation. The fifth is that recommendations from science on how to set FRELs is not clear. The last reason is that the very nature of FRELs make them trickier than other numbers as FRELs are hypothetical scenarios about what would happen in the absence of REDD+.

He further lists four practical examples on how gaming could occur in the context of REDD+

1. The choice of historical reference period to estimate average historical rates of deforestation, to report higher FRELs
2. By including upward trends in deforestation rates, but not downwards trends, in the predictions of future deforestation in the absence of REDD+ policies

3. The selective inclusion of REDD+ activities which have higher likelihood of success
4. Choosing global (Tier 1) emission factors when national, more uncertain but lower emission factors are available.

In addition, here are some more examples I could think of:

5. Choosing to use global deforestation rates when the national globalization rate is lower than the global average.
6. Adjusting upwards by including national circumstances.
7. Using methods of constructing emission factors which yields the highest emissions

The analysis will investigate whether there are patterns of gaming in three specific areas. The first is the use of reference period length. Countries must choose a reference period to calculate their historical average from. The most common method when using the historical average approach is to use a 10-year reference period. There are, however, a lot of countries which deviates from this practice by using a longer or shorter reference period. I want to investigate how the deforestation levels when deviating from the 10-year period compares to using a 10-year period. Thus, my first hypothesis is

> *Hypothesis 1: countries which deviate from the "standard" method of calculating their reference level (10-year historical average) get a higher reference level by deviating.*

The second area of interest is the countries which use the trend extrapolation method. I will review the submission of the countries which use this method to calculate their FREL/FRL This is based on the second example from Angelsen (2018) above. If countries which have an upwards trend in emissions from REDD+ activities use this method, they will get an increasing FREL which is higher than the level from using a historical average. Gaming behavior would be that only countries with increasing trends use this method. My second hypothesis is therefore:

> *Hypothesis 2: Countries which use trend extrapolation for setting their FREL/FRL tend to have upwards trend and thus get a higher FREL compared with the historical average.*

The third and last element which I will investigate is adjustment for national circumstances. Countries could be taking advantage of the vague guidelines and adjusting their FREL upwards to a higher level compared to the historical average. My third hypothesis is:

> *Hypothesis 3: Countries that adjust their reference level for national circumstances adjusts upwards and get a higher FREL compared with the historical average*

The third point in the practical examples of gaming provided by Angelsen is gaming through being selective with the REDD+ activities is an interesting area but is not something I was able to investigate. Investigating this it would require a more in-depth knowledge of each country's ability in implementing the five REDD+ activities and much more time than I had for this thesis. The same goes for the construction and use of different emissions factors and forest definitions.

It is important to mention that since the UNFCCC guidelines are vague, there is no correct or standardized way of creating a reference level. Differences in methods, reference periods or inclusions of national circumstances that give higher reference levels might be legitimate inclusions even though it might look like gaming. Gaming only occurs of the intent of including certain factors or choosing a certain reference period is to receive higher payments or better emission reduction results. Unfortunately, it is not possible to know the true intent of the people responsible for creating the reference levels. Therefore, it is not easy to find gaming at the individual country level. However, through the results of my analysis, I hope to be able to see, by looking at the overall tendencies and patterns, whether there is gaming behavior or not.

4 Method and data

This section describes in detail the data and methods used in the analysis. Section 4.1 and 4.2 describes the datasets and sections 4.3, 4.4 and 4.5 describes the methods for testing each of the three hypotheses.

4.1 UNFCCC Submissions (Submission data set)

The analysis uses two data sources. The first source is the UNFCCC REDD+ country submissions. 56 countries have submitted their proposed reference levels for forest emissions, also referred to as FRELs/FRLs as of March 2022. The submission can be found at the UNFCCC REDD+ website (UNFCCC, 2022a). From these 56 submission documents, I created my own dataset in an Excel spreadsheet. I used the newest submissions available for each country. That meant that for some party countries the initial submission was used and for others the revised submission. The revised submissions are submissions which is are re-submitted after the first attempt has gone through the UNFCCC technical assessment. From each submission a collected a set of variables:

- Year of submission
- Start year and end year of reference period, then calculated each duration
- Method of constructing the reference level (historical average, trend extrapolation, etc.)
- Forest definition (canopy cover percentage, tree height and land size in ha)
- Whether the reference level was national or subnational
- REDD+ activities included in the reference level:
    - Reducing emissions from deforestation
    - Reducing emissions from forest degradation
    - Conservation of forest carbon stock
    - Sustainable management of forests
    - Enhancement of forest carbon stock
- Inclusion of national circumstances in estimation of FREL/FRL and info on:
    - What was the adjustment
    - Size of adjustment
    - Justification of adjustment

4.1.1 The Scope of activities in the submissions

Table 2 shows the number of times (or how many party countries included), each REDD+ activity was included out of the 56 submissions:

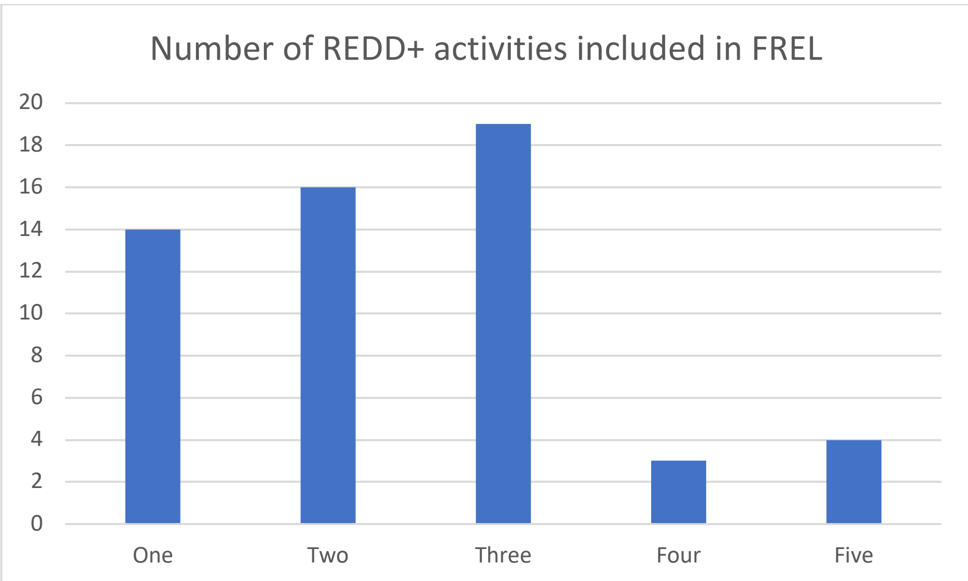
Table 2: The frequencies of each REDD+ activity

Activity	Inclusions	Share of total
Reducing emissions from deforestation	54	96.4%
Reducing emissions from forest degradation	32	57.1%
Conservation of forest carbon stock	9	16.1%
Sustainable management of forests	8	14.3%
Enhancement of forest carbon stock	33	58.9%

Source: Submission dataset

"Reducing emissions from deforestation", or just deforestation, was the most included REDD+ activity with an inclusion rate of 96.4%. Only India and Dominica did not include deforestation in their FREL submission. Dominica lost approximately 90% of their forest cover classified at forest lands during the 2017 hurricane "Maria", and thus only include restorative or conservational activities (conservation and enhancement of forest carbon stock and sustainable management of forests) in their FREL. India only includes "conservation of forest carbon stock" as their only REDD+ activity and is the only country to do so. Figure 11 shows the frequencies of how many activities that were included. The most common number was to include three REDD+ activities, with the combination of deforestation, forest degradation and enhancement of forest carbon stock being the most common.

Figure 11: The Number of REDD+ activities included in the submissions



Source: Submission dataset

4.1.2 Forest Definitions

The tables below show the different distribution for each of the three forest definition components. The most common forest definition is the FAO (2020c, p. 4)forest definition which is 0.5 ha, tree height of 5 meters, and a 10% canopy cover.

Table 3: Canopy cover level frequency in the submissions

Canopy cover	10%	15%	20%	30%	60%	Total
Inclusions	25	2	3	24	2	**56**

Source: Submission dataset

Table 4: Tree height frequency in the submissions

Tree height	2m	3m	4m	5m	6m	7m	Not available	Total
Inclusions	8	7	3	33	0	1	4	**56**

Source: Submission dataset

Table 5: Forest area level frequency in the submissions

Area (ha)	0.1 ha	0.4 ha	0.5 ha	1 ha	6.25 ha	Not available	Total
Inclusions	1	1	30	22	1	1	**56**

Source: Submission dataset

4.2 Global Forest Change (Hansen) data on deforestation

The second source of data I used was the Global Forest Change (GFC) data (Hansen et al., 2013), sometimes referred to as "the Hansen data", which is a dataset containing the annual forest cover loss of each country in the world, both nationally and sub-nationally, between the years 2001 and 2020 and is continually updated. With this dataset it is possible to calculate historical averages deforestation levels which I need when looking at the differences in choice of reference periods. The data also allows me to find the trend in deforestation for each country which is useful when looking at the countries using the trend extrapolation method and those who adjust for national circumstances.

The Hansen data has the forest cover loss for eight different levels of the canopy cover: 0%, 10%, 15%, 20%, 25%, 30%, 50% and lastly 75%. From the Hansen data I extracted the forest cover loss between 2001 and 2020 for each of the REDD+ participating countries. I used the same canopy cover percentage as the countries used in their submissions, and for the two countries (Dominica and Saint Lucia) which used a 60% canopy cover, I used the 50% cover.

There were seven countries which submitted a *sub-national* reference level: Argentina, Brazil, Chile, Guinea-Bissau, Liberia, Peru and Sudan. It was possible to extract the sub-national forest cover loss for Argentina, Chile and Sudan from the Hansen data and for Brazil the submission deforestation numbers were used. For Guinea-Bissau, Liberia and Peru I was not able to find data in the sub national regions which these countries included in their submission and thus I used the national forest cover loss data for these.

4.3 Reference period test method

The countries were divided into three groups: those with a reference period less than 10 years, those with 10 years exactly, and those with a reference period above 10 years. The first and last group are the "deviants" (the test groups), and the 10-year group is the control group. Then I calculated the average deforestation level for the submitted reference period of those who deviates, and then calculate the average deforestation for the same countries if they were to use the "standard", or more common, 10-year method. I changed the reference period by changing the starting year and using the same ending year. A reference period from 2001 to 2018 (18 years) would be changed to 2009-2018 (10 years) and a country with a reference period less than 10 years, say between 2011-2018 (8 years), would extend to 2009-2018 (10 years). Both examples are illustrated below in figure 12 and 13.

Figure 12: Original and test reference periods

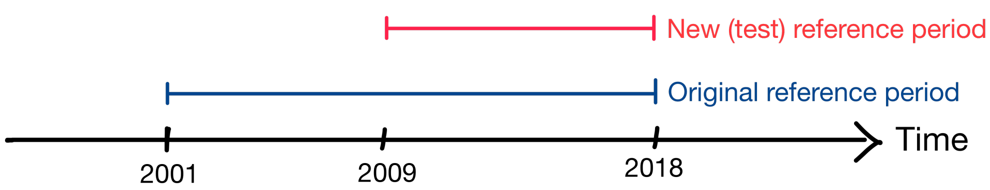
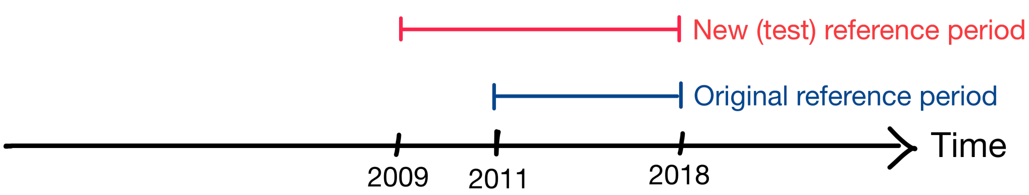


Figure 13: Original and test reference periods



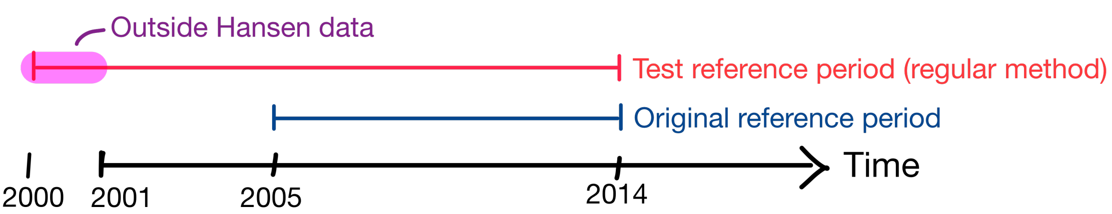
For the control group I calculated their deforestation level from the submitted reference period, which is ten years, and then calculated the average deforestation level for a 15-year reference period to compare. When changing the reference period for the control group I extended the starting year and held the end year put just like the test group. The reason why I choose the 15-year reference period is that among the deviants, the 15-year period was the most common reference period.

One should note is that some countries use a reference period which ends long before the submission date. An example is if a country submits their FREL in 2019 but the reference period used is between 2001-2010. It is possible to test whether the choice of reference period years have an impact and not the duration, but there are few countries that does this and for the purposes of this analysis only the differences in duration was tested.

4.3.1 The exceptions

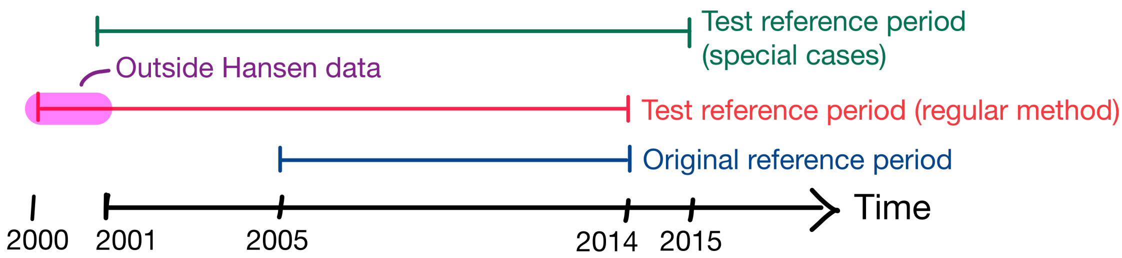
There are those party countries use a utilize a reference period which is outside the Hansen data set, meaning they use a reference level which starts before 2001 which is the first year of the Hansen dataset. These are Brazil (1996-2015), Costa Rica (1997-2009), Burkina Faso (1997-2017) and Viet Nam (1996-2010). Only Brazil provided annual deforestation numbers and Costa Rica provided annual emission from deforestation numbers. Burkina Faso and Vietnam is therefore excluded from this analysis. In Brazil's case, they do provide year by year deforestation and thus I calculated their average deforestation from these numbers. The data provided by Brazil is already sub-national. Costa Rica is different as they do not provide deforestation in hectares but in emission from deforestation. Therefore, I used the emissions from deforestation numbers to calculate the average emissions during their submission reference level and the average for the new 10-year reference level so see whether they gain or lose by using their submission reference period just like the other countries.
Then there are the countries where their submission reference period fits within the Hansen data, but the "new" hypothesis reference period is outside of the Hansen data. This is the case for Gabon, India, Bhutan, Laos, Nepal and Sri Lanka. India and Dominica did not include deforestation in their FRELs/FRLs and thus I exclude them for this part of the analysis. To include these five other countries in this part of the analysis I made the new hypothesis reference periods fit within the Hansen data set by extending the starting year as long as I could, such as with the rest of the countries, but once they reached 2001 and I could not extend them any longer backwards, I extended the ending year of the periods. For example, Bhutan is in the control group as they use a 10-year reference period. Bhutan's' original submitted reference period was between 2005 to 2014 and if I were to extend the reference period to 15-years with only changing the starting year, the period would have been 2000 to 2014 which is outside of the Hansen data as illustrated in figure 14 by the red line.

Figure 14: Reference period when it is outside of the GFC/ Hansen data



Therefore, in the case of Bhutan and the other mentioned in this paragraph, the ending year was changed so that in Bhutan's' case it would be between 2001-2015 as illustrated in figure 15 by the green line:

Figure 15: Reference period when it is outside of the GFC/ Hansen data



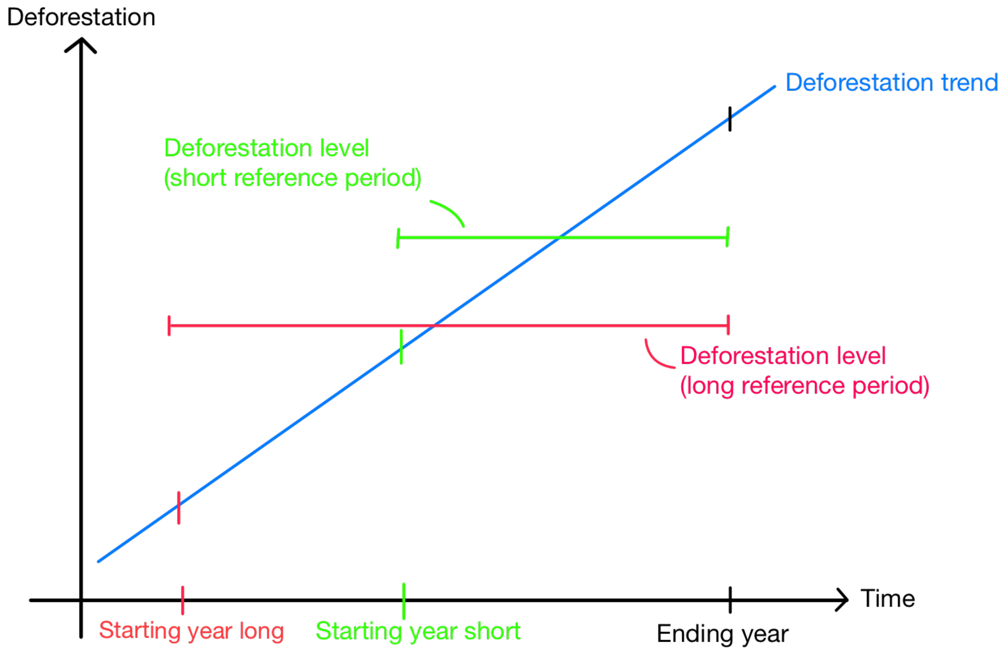
Finally, there were five countries which in their submission used the trend extrapolation method. I used the same reference period they used in their submissions and calculated the historical averages for these countries in order to include them in the analysis.

4.3.2 Calculating trends

I calculated the deforestation trend for these countries using the Hansen data by doing a simple regression where deforestation is the dependent variable and year was the independent variable, restricting the regression to the submitted reference period for each country. For the countries which have a reference period which start before 2001, the starting year was set at 2001. This is the case for Brazil, Burkina Faso, Costa Rica and Vietnam as seen in the appendix, Table 21.

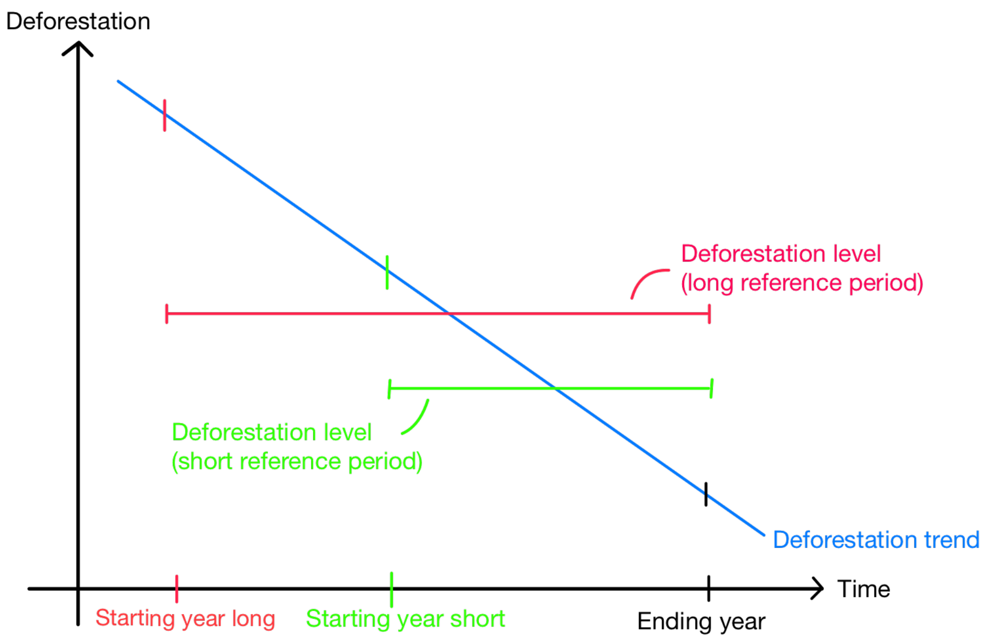
When looking at deforestation trends it is interesting to see how many countries have an upwards trend and how many have a downwards trend. Countries with an upwards trend in deforestation would gain by having a shorter reference period, keeping the ending year of the reference period the same. This is shown in Figure 16 below:

Figure 16: Upwards deforestation trend and reference period lengths



The opposite is true for countries with a downwards trend in deforestation as shown in Figure 17 below:

Figure 17: Downwards deforestation trend and reference period lengths



4.4 Reviewing trend extrapolation countries

The second part of the analysis reviews the reference level submission of the party countries which used the trend extrapolation method to calculate their reference level to investigate the direction of the trend. The FRELs/FRLs for each country was collected from the submission and found the trends in deforestation through the method mentioned above in part 4.2.2.

4.5 Reviewing adjustments for national circumstances

The third and final part of my analysis is aimed at testing the third hypothesis which is that countries that adjust their reference level for national circumstances adjusts upwards. The country submissions which included adjustments for national circumstances were reviewed to find the pre- and post-adjustment reference levels and the justification for the adjustments as long as it was provided in the submissions.

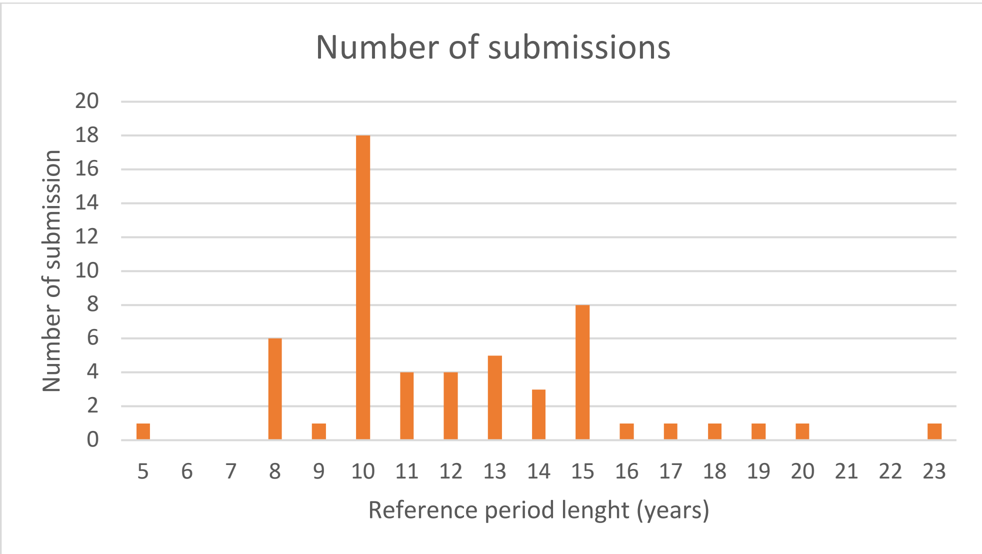
5 Results & discussion

The results are structured so that each part answers each of the hypothesis. Part 5.1 presents the reference period results, 5.2 presents the results from reviewing the country submission using the trend extrapolation method and part 5.3 show the results from reviewing adjustment for national circumstances.

5.1 Reference period results

52 countries were included in this test and 4 were excluded. India and Dominica since they did not include deforestation, and Vietnam and Burkina Faso due to their submission reference period was outside the Hansen data. There were 29 countries in the two deviating/test groups if we exclude those countries which used the trend extrapolation (5). There were 23 countries which used a longer than 10-year reference period (28 including the trend extrapolation countries) and 6 countries which used a shorter than 10-year reference period. In the control group, the countries which used the 10-year reference period, there are 18 countries. Figure 18 show the distribution of reference period duration.

Figure 18: Frequency of different lengths of the reference period in the submission



The tables below show the differences in the average annual deforestation level (in hectares) by using the submission period and in the test period on the left-hand side. The countries with a positive difference have a higher deforestation level from using the submission reference period and these are called the beneficiaries because they benefit from deviating from the 10-year reference period length. The countries with a negative difference have a lower deforestation level by using the submission reference period and are called the losers because they lose out by deviating from the 10-year reference period length.

On the right-hand side is the deforestation trend for each country using the submission reference period. This is the expected change in deforestation level.

Table 6: Reference period of more than 10 years test group) using the GFC/ Hansen data

	Deforestation (in hectares)			**Trend submission period**		
Country	**Submission**	**Test (10-year)**	**Difference**	**Trend coefficient(ha)**	**T-value**	**Direction**
Argentina	95 969	105 406	-10%	4 046	1.34	Up
Bangladesh	5 943	7 068	-19%	551**	2.89	Up
Belize	11 249	12 778	-14%	667**	2.61	Up
Brazil	1 402 920	705 788	50%	-83 759**	-2.96	Down
Chile	81 206	86 605	-7%	3 174**	2.44	Up
Côte d'Ivoire	125 353	141 337	-13%	8 024	1.68	Up
Congo	24 674	24 475	1%	1 067	1.67	Up
Dominican Republic	15 224	15 149	0%	47	0.21	Up
Ecuador	43 061	47 695	-11%	1 392	1.31	Up
Ethiopia	22 682	25 219	-11%	1 981***	3.86	Up
Ghana	57 897	63 374	-9%	3 702	1.62	Up
Guyana	4 075	4 046	1%	167	1.09	Up
Honduras	57 139	72 380	-27%	4 470**	2.57	Up
Indonesia	1 548 013	1 566 402	-1%	-23 587	-0.95	Down
Kenya	23 511	23 805	-1%	209	0.96	Up
Malaysia	460 039	468 501	-2%	16 246	1.72	Up
Mozambique	156 208	163 864	-5%	6 060	1.75	Up
Saint Lucia	51	61	-18%	3*	1.94	Up
Sudan	96	83	14%	-19***	-3.59	Down
Togo	2 921	3 295	-13%	210*	1.81	Up
Uganda	34 004	41 034	-21%	2 728***	4.55	Up
Tanzania	193 461	198889	-3%	14 751***	5.55	Up
Using emissions (tCO_2)				Deforestation (ha)		
Costa Rica	8 590 840	7 033 222	18%	1 007	1.6	Up
Countries which use trend extrapolation						
Malawi	15 164	15 780	-4%	1 218**	3.25	Up
Papua New Guinea	53 779	57 651	-7%	2 046**	2.69	Up
Solomon Islands	8 465	11 463	-35%	992***	8.07	Up
Suriname	9 695	14 142	-46%	961***	11.38	Up
DPR Congo	586 858	657 123	-12%	47 181***	2.75	Up

*** significant at the 1% level, ** significant at the 5% level, * significant at 10% level

Table 7: Reference period of less than 10 years (test group) using the GFC/Hansen data

	Deforestation (in hectares)			Trend submission period		
Country	**Submission**	**Test (10-year)**	**Difference**	**Trend coefficient(ha)**	**T-value**	**Direction**
Cambodia	174 710	176 372	-1%	-10 900***	-4.05	Down
Equatorial Guinea	11 197	8 821	21%	-1 830	-1.33	Down
Guinea-Bissau	14 416	12 857	11%	2 957**	2.7	Up
Pakistan	878	887	-1%	-129	-3.18	Down
Paraguay	345 193	366 668	-6%	-18 497	-1.5	Down
Special case to fit Hansen data (in ha)						
Gabon	16 098	15 556	3%	531**	3.19	Up

*** significant at the 1% level, ** significant at the 5% level, * significant at 10% level

Table 8: Reference period of 10 years (control group using the GFC/ Hansen data

	Deforestation (in hectares)			Trend submission period		
Country	**Submission**	**Test (10-year)**	**Difference**	**Trend coefficient(ha)**	**T-value**	**Direction**
Colombia	228 195	220 396	3%	10 759	1	Up
El Salvador	3 061	4 080	-33%	-217***	-3.52	Down
Guatemala	82 450	79 207	4%	1 270	0.19	Up
Liberia	128 446	94 579	26%	21 028***	5.83	Up
Madagascar	193 548	158 099	18%	27 779***	3.51	Up
Mexico	214 266	202 142	6%	1 935	0.37	Up
Mongolia	28 631	29 676	-4%	-5 188*	-1.92	Down
Myanmar	208 510	165 044	21%	22 348***	5.98	Up
Nicaragua	70 894	64 695	9%	-2 951	-0.83	Down
Nigeria	132 650	105 978	20%	8 679**	2.6	Up
Panama	22 604	20 265	10%	-2 677***	-3.89	Down
Peru	210 153	184 916	12%	9 520	1.83	Up
Thailand	124 313	110 530	11%	6 521***	2.41	Up
Zambia	216 340	175 853	19%	17 026*	2.22	Up
Special cases (starting and ending year was changed to fit Hansen data)						
Bhutan	1 222	1 012	17%	58	0.97	Up
Lao PDR	145 875	132 881	9%	14 851***	4.62	Up
Nepal	3 032	2 766	9%	247	1.8	Up
Sri Lanka	6 810	8 513	-25%	863*	2.68	Up

*** significant at the 1% level, ** significant at the 5% level, * significant at 10% level

5.1.1 Test group results

Looking at those who use a longer reference period than 10 years in table 9, excluding those who use trend extrapolation, 17 countries (73.9%) had a *lower* deforestation rate by using the submission reference level. Only 6 countries (26.1%) had a higher deforestation rate by deviating from the 10-year standard. This result disproves the first hypothesis. If we were to include the trend extrapolating countries by using the same reference period length and calculating an historical average for these countries, then the number of countries which lose out by deviating is 22 (78.6%) and the number who benefits from deviating is 6 (21.4%).

For the countries using a reference period shorter than the 10-year period, the results show that half (3 of 6) benefits from deviating from the 10-year period, while the other half lose.

Table 9: Beneficiaries and losers (test group)

	Method submission	Losers	Beneficiaries
Test Group 1: More than 10 years	Historical Average	17 (73.9%)	6 (26.1%)
	Including Trend Extrapolation countries using historical average	22 (78.6%)	6 (21.4%)
Test group 2: Less than 10 years	Historical Average	3 (50%)	3 (50%)
Total control groups	Historical Average	20 (70%)	9 (30%)
	Including Trend Extrapolation countries using historical average	25 (73.5%)	9 (26.5%)

Excluding the countries which use trend extrapolation and only looking at countries which use an historical average, the total number of countries which have a lower annual rate of deforestation by using a non-10-year reference period is 20 (70%) and the number of countries which gain is 9 (30%). Including the trend extrapolation countries, the number is 25 (73.5%) that lose and 9 (26.5%) that gain.

Looking at the average deforestation of the beneficiaries and the losers there are some interesting results as we can see in table 10 below. Costa Rica, which is in the beneficiary group, is excluded from this table because the only available numbers for their reference level was in tCO2 emissions and not deforestation in hectares. The full calculations are presented in tables 22 and 23 in the appendix.

Table 10: Summary of test group results

	Number of countries	Total average deforestation submission period (ha)	Total average deforestation test period (ha)	Gained	Lost
Beneficiaries	9	1 488 700	786 775	701 926	0
Losers	25	4 113 447	4 327 800	0	-214 353

The beneficiaries gain 701 926 hectares of deforestation annually even though there are only eight countries in this group. The losing group only loses 214 353 hectares which is small considering the group consist of 24 countries. Why is it so? Looking at the two largest countries Brazil and Indonesia gives us a little more insight.

Brazil is the biggest country among the group which benefits by using the submission reference period. It makes up 94% of the total deforestation from this group. By using a 20-year reference period (1996-2015) rather than a 10-year (2006-2015), they gain 697 132 hectares of deforestation in their FREL. Indonesia, which is among the countries which lose out by using the submission reference period, lose only 18 389 hectares by deviating. In other words, Brazil is the big winner in this equation.

5.1.2 Control group results

Table 11 below shows that most of the countries in the control group benefits from using the submission reference period, 10-year, as opposed to a 15-year period. 15 countries have a higher deforestation rate using the 10-year annual average and only 3 countries have a lower deforestation rate when compared to a 15-year reference period.

Table 11: Beneficiaries and losers (control group)

	Method submission	Losers	Beneficiaries
Control group	Historical Average	3 (16.7%)	15 (83.3%)

In the control group, we see from Table 12 that the 15 beneficiaries gain a total of 264 136 hectares to their total deforestation level by using the standard 10-year method, and that the losing group only lose out on a mere 3 767 hectares. It is a small number but there are only three countries in this group.

Table 12: Summary of control group results

	Number of countries	Total average deforestation submission period (ha)	Total average deforestation test period (ha)	Gained	Lost
Beneficiaries	15	1 981 499	1 718 363	264 136	0
Losers	3	38 502	42 270	0	-3 767

5.1.3 Trends

Looking at the trends in the test groups, 27 countries have an upward trend in deforestation and only 7 have a downwards trend, using the Hansen data. Among the 25 countries which have a lower deforestation rate by using the submission reference period, 21 have an upwards trend in deforestation, and only four has a downwards trend.

In the control group, out of the 3 that lose, 2 have a downward trend and 1 has an upwards trend in deforestation. Among the 15 beneficiaries, 2 have a downward trend and 13 an upwards trend.

This makes sense because with an upwards deforestation trend, keeping the ending year of the reference period the same, countries will get a lower average deforestation rate by having a longer reference period trend. The opposite is the case for countries with a downwards trend. Keeping the ending year constant, a longer reference period would increase the average

5.1.4 Summary of reference period results

Table 13 show the total of countries that would gain or lose by switching reference period length.

Table 13: Number of countries that would gain or lose by switching reference period

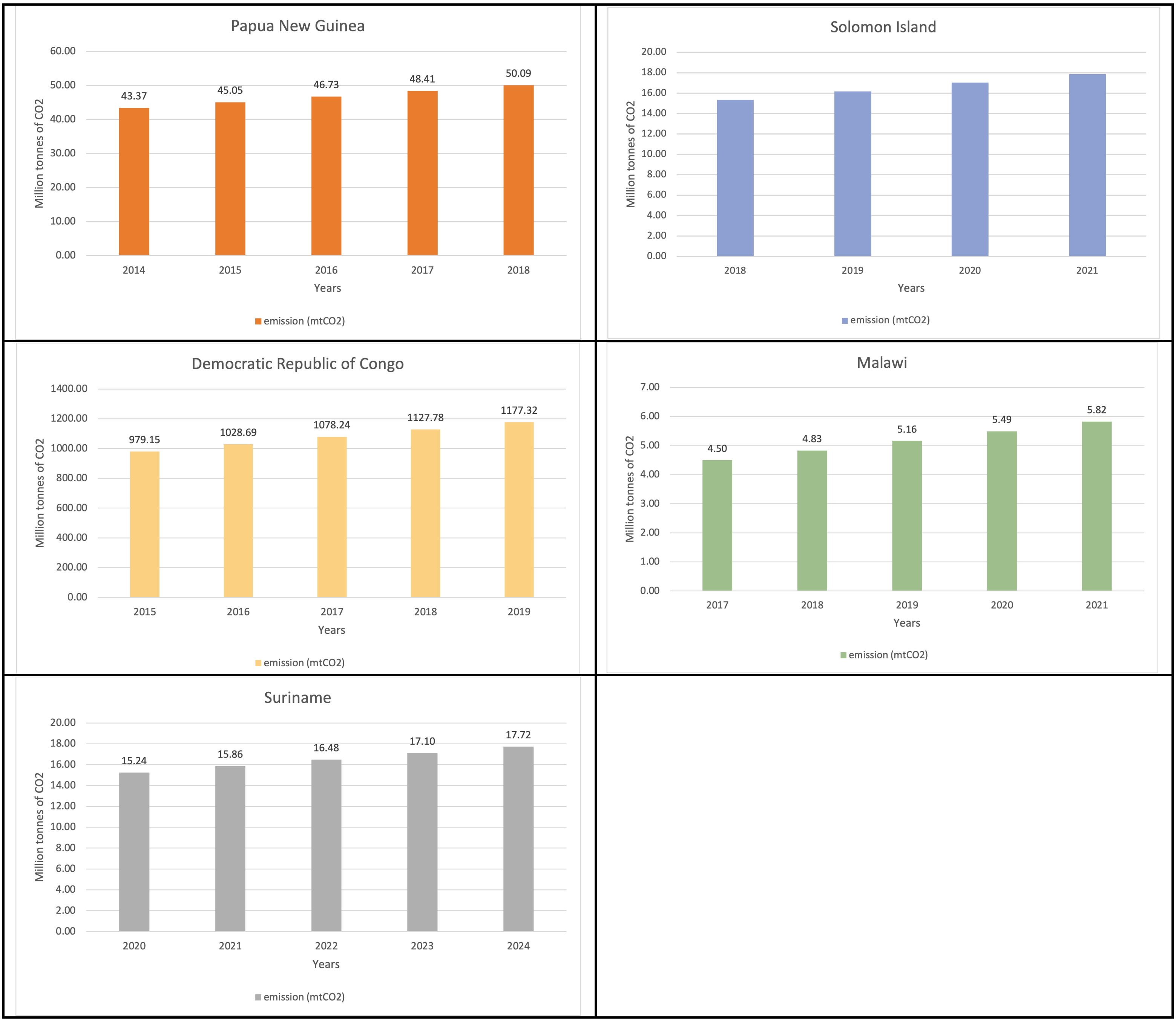
Reference period	Gain	Lose
From >10 year to 10 year (test group)	22	6
From 10 year to 15 year (control group)	3	15
From <10 year to 10 year (test group)	3	3
Total	**28**	**24**

In short, these results are not in line with the first hypothesis. Rather, we see that most countries would actually benefit by switching to the 10-year historical average method. However, among the countries which already use the 10-year period, the majority is benefitting from it compared to a 15-year period. Yet, the result suggests that in the case of reference periods, there seems to be little gaming of the system.

5.2 Results from reviewing the use of trend extrapolation

There are five countries which use the trend extrapolation method to construct their reference level and these countries are The Democratic Republic of Congo, Malawi, Papua New Guinea, Solomon Island and Suriname. Figure 19 show the FRELs/FRLs from the submissions of these five countries

Figure 19: FRELs of countries using trend extrapolation



Source: Submission dataset

Table 14: Deforestation trends using the GFC/Hansne data for countries using the trend extrapolation method

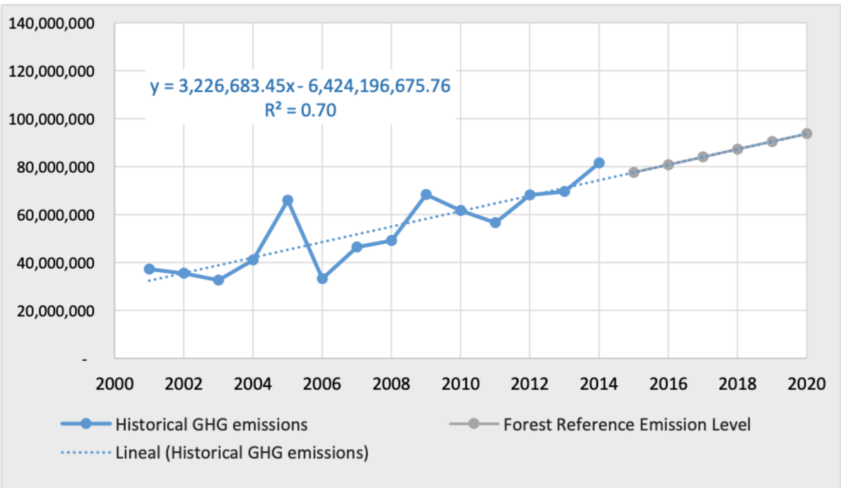
	Reference period			Trend		
Country	**Start**	**End**	**Duration**	**Trend coefficient(ha)**	**T-value**	**Direction**
DPR Congo	2001	2014	14	47 181**	2.75	Up
Malawi	2006	2016	11	1 218**	3.25	Up
Papua New Guinea	2001	2013	13	2 046**	2.69	Up
Solomon Islands	2001	2017	17	992***	8.07	Up
Suriname	2001	2019	19	961***	11.38	Up

*** significant at the 1% level, ** significant at the 5% level, * significant at 10% level

These results confirm the second hypothesis as all the countries have an upwards trend in deforestation. If a country has an upward trend in deforestation and it wanted a high reference level, then the trend extrapolation method will be superior to the historical average method. There is of course no way to know the true intent of the participating countries, but from these results it certainly looks like countries use the vague guidelines to their advantage and thus are gaming the system.

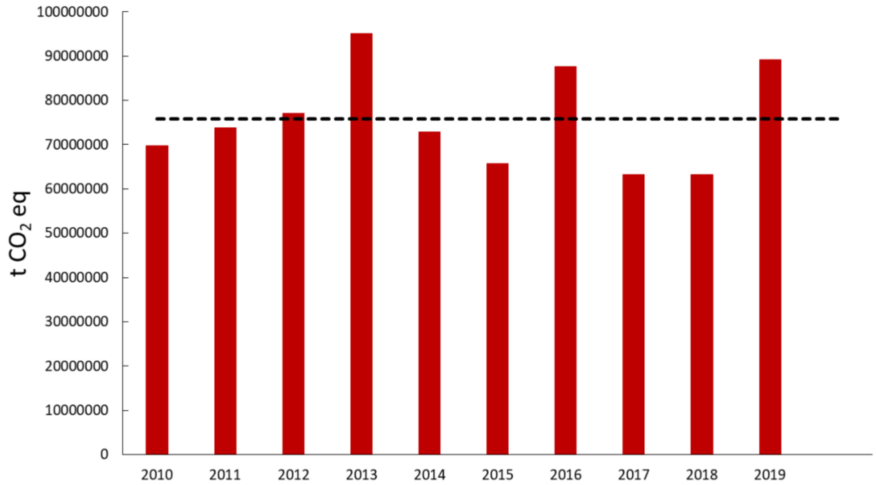
An interesting case which also is in line with the second hypothesis is Peru. Peru used the historical average method in their most recent submission from 2021, they did however use the trend extrapolation method in the previous submission from 2016. The two figures below are gathered from these two submissions, and they show the emission trend and the subsequent FREL.

Figure 20: FREL using trend extrapolation



source (Peru, 2016, p. 23)

Figure 21: FREL using historical average



Source: (Peru, 2021, p. 100)

What is interesting here is that the in their 2016 submission, when they used the trend extrapolation method, the emission trend was going upwards. In the 2021 submission however, the trend was almost horizontal. It looks like once the incentive to use the trend extrapolation is no longer there, Peru switched method.

One should also take into consideration that newer submissions usually have better and more precise and updated data and methodology, which can help to explain this shift in FREL/FRL calculation method.

5.3 Results from reviewing adjustments for National Circumstances

There are a total of eight countries that adjusts their reference level by taking national circumstances into account. Six of them classify as High forest, low deforestation (HFLD) countries. A HFLD country is a country in the early stage of the forest transition theory, in which there is an expected rise in economic activity and thus expected increase in deforestation in the foreseeable future. In the following paragraphs I will present each country and, if provided in the submission, their reference level pre and post adjustment as well as their justification for the adjustment. A summary of the findings is presented in table 15 below followed by a more detailed account for each of the nine countries

Table 15: Summary of adjustments for national circumstances

Country	Adjustment	FREL/FRL (mtCO2) Before	After	Increase
Bhutan	0.1% of biomass carbon stock & delayed emissions from soil from deforestation.	0.15	0.50	216%
Colombia	Logistic model for each of five biomes combined with historical average.	91.65	120.77 (2018) 127.01 (2019) 132.52 (2020) 137.13 (2021) 140.73 (2022)	31% 38% 44% 49% 53%
Congo	Including emissions related to future planned deforestation and forest degradation. Accounting for concession already given by the government to mining and agro-industrial sectors.	19.21	35.47	84%
Costa Rica	Excluding non-anthropogenic, non-human, sources of GHG emissions.	Not Available	14.91 4.36	Not Available
Gabon	Adjust at the maximal permitted level according to the GFC scorecard which is 10% of the FRL spread over the results period	35.07	38.58	10%
Vietnam	Removing the effects of successful reforestation programs which were implemented in the 1990s	– 47.79	-39.60	17%
		Use forest carbon stock loss rates		
Guyana	Using "combined approach" which uses the average between the global and national carbon stock loss rate.	0.049%	0.242%.	393%*
		Carbon stock measured in mtC		
Dominica	Not including forest carbon stock from before the 2017 hurricane Maria, and instead use the 2018 post hurricane carbon stock as its benchmark.	0.32	0.60	- 86%

*Increase in size, not percentage points

Source: Submission dataset

Bhutan

Bhutan applies an upwards adjustment of 0.1% of the biomass carbon stock. The justification for this is that they classify as a *"high forest low deforestation"* (HFLD). Bhutan also adjusts for delayed emissions from soil from deforestation during the reference period. The adjustment only applies to the FREL which in Bhutans case is emissions from deforestation as forest degradation is not included.

The unadjusted FREL is at 159 780 tCO2e per year and the adjusted FREL is at 505 837 tCO2 per year, which is a 216% increase. 335 331 tCO2e of the increase is due to the 0.1% adjustment of the biomass carbon stock, and about 10 725 tCO2e is due to the delayed emission from the soil.

Colombia

Colombia adjust their FREL for national circumstances using a logistic model which were developed for the five biomes included and then aggregated to get a national result. Note here that I did not include Colombia as a trend extrapolation country even though they have an increasing FREL. The reason in that in their calculation they use a combination of historical averages and the logistic model. The Colombian FREL only includes deforestation. The model results give Colombia an increasing FREL for the results period 2018-2022 which increases by 53%. Their unadjusted historical average between 2008-2017 is at 91 652 448.54 tCO_2e per year. Table 16 show the Colombian FREL after adjusting for national circumstances.

Table 16: Colombian FREL after adjusting for national circumstances

Year	**tCO_2e per year**
2018	120 770 431
2019	127 011 963
2020	132 520 275
2021	137 130 393
2022	140 732 334

Source: Submission dataset

Congo

Congo adjusts upwards for National Circumstances by including emissions related to future planned deforestation and forest degradation. Their justification for this inclusion is that the Congolese government has issued concession to the mining and agro-industrial sectors which will lead to deforestation and forest degradation in the results period (2015-2020). The concessions are in place to reduce the country's food dependency. Congo also classify as a HFLD country.

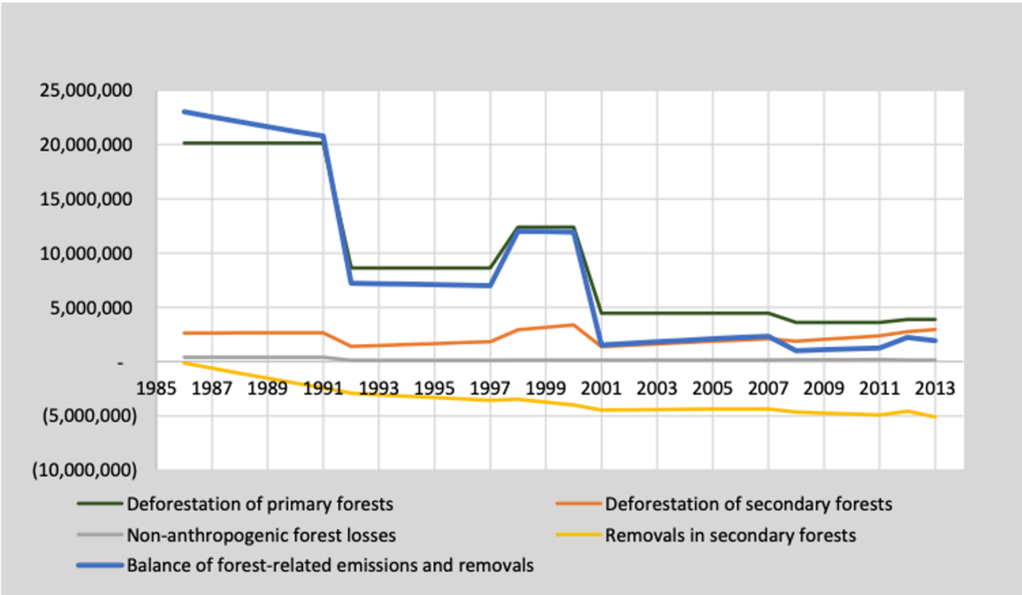
The unadjusted historical average emissions, the FREL, from the reference period 2000-2012 is 19 208 572 tCO_2e per year. The adjusted FREL is at 35 475 652 tCO_2e per year, an increase of 84%. Future emissions due to forest degradation makes up 2 655 357 tCO_2e per year and emissions from deforestation makes up 13 611 724 tCO_2e per year, meaning the total adjustment is at 16 267 080 tCO_2e per year.

Costa Rica

Costa Rica adjust their FREL for national circumstances by excluding non-anthropogenic, non-human, sources of GHG emissions. The adjustment is justified on the grounds that Costa Rican forests are highly vulnerable to different types of extreme weather and natural disturbances which are non-anthropogenic and that such factors should not be included in the estimates for a result-based payments scheme. Among the types of natural disturbances mentioned are volcanic activity, flooding, earthquakes, etc.

Costa Rica has two different FRELs. One for the period 1997-2009 which is at 14 911 467 tCO2e per year and one for the period 2010-2025 which is at 4 365 160 tCO2 per year. Figure 21 is from Costa Ricas submission and shows that non-anthropogenic emissions accounts for a very little of the total emissions. Is the exclusion of the non-anthropogenic emissions beneficial or not? It did not have much impact on the pervious emissions, but it might have a large impact on future emissions if a natural disaster or more extreme weather occurs. By excluding non-anthropogenic sources of emissions, Costa Rica could be hedging their FREL emission levels, reducing the risk of a natural disaster increasing their FREL in the future.

Figure 22:Forest-related emissions and removals in Costa Rica between 1986 and 2013 (tCO2-e yr^{-1})



Source: Costa Rica´s submissions (2016, p. 20)

Dominica

Dominica is one of the two countries which do not include deforestation in its FRL. Forest degradation is also not included as Dominica's FRL only consist of the carbon stock preservative activities (enhancement, conservation and sustainable management of forest carbon stock). Dominica adjusts its FRL for national circumstances by not including forest carbon stock from before the 2017 hurricane Maria, and instead use the 2018 post hurricane carbon stock as its benchmark.

In their submission Dominica state that during hurricane Maria in 2017, an estimated 85% to 95% of the country's forest cover were lost. The pre 2017 forest carbon stock level was at 6 325 645 tC and the post hurricane level was at a mere 606 778 tC which is a 86% decrease. A decrease in carbon stock level is the same as an upwards adjustment in emissions as the level is easier to reach. The level of success and result based payments would be measured as the increase in the forest carbon stock level compared to 2018 levels.

Gabon

Gabon adjust their FRL upwards by accounting for national circumstances. They adjust at the maximal permitted level according to the GFC scorecard which is 10% of the FRL spread over the results period. They justify the adjustment on the grounds that Gabon is a HFLD country and that one of the core principles within the constitution is to protect the natural environment. The pre adjustment FRL which includes all REDD+ activities, is at 35 072 131 tCO_2e per year and the adjusted FRL is at 38 579 344 tCO_2.

Guyana

Guyana classifies themselves as a HFLD country. Guyana's method of constructing their FREL is what they call an "combined approach" which is using the average level between its national forest carbon stock loss rate between 2001-2012) and the global carbon stock loss rate. This is also the method used in their agreement for result-based payment with Norway from 2010. The average global forest carbon stock loss rate they use in the UNFCCC submission is 0.435% and the national rate is 0.049%, and then use the average of these two: 0.242%. As such, using a higher rate than their national rate. From this they construct their FREL in tCO_2 which is at 46 301 251tCO_2e per year.

Vietnam

Vietnam adjusts their FRL for national circumstances by excluding removals which is an upward adjustment. The pre-adjusted FRL is at – 47 786 072 tCO_2e annually and after the adjustment the FRL is at -39 605 735 which is a decrease of 17%. They justify the adjustment by removing the effects of successful reforestation programs which were implemented in the 90s, with the main project being program 661 the "Five Million hectare Reforestation Programme". This program lasted between 1998-2010 and Vietnams reference period is between 1996-2010. They estimate that about 123 000 000 tCO_2e has been stocked during the reference period due to the reforestation programs and are therefore removed from the FRL. Again, this is the same as an upwards adjustment of the emissions because the new benchmark is easier to reach.

5.3.1 Concluding remarks on adjustment for national circumstances

Looking at the results from this review, most countries do adjust their reference level upwards which means in a result-based payment system that they will receive more payments for the same emission levels. This confirms the third hypothesis. As mentioned earlier, it is important to note that it is impossible to know the true intent of the participating countries. However, from the aggregate results it seems that gaming is taking place.

6 Conclusion

Using data from the REDD+ country submission combined with the Global Forest Watch/Hansen deforestation data, the results show what looks like "gaming" behavior in two out of three areas which were investigated. In the choice of reference period length, the suspicion was that the reason why a lot of countries deviated from the "standard" 10-year length was that they got a higher deforestation level. However, the results show that the majority of countries that deviate from this length get a lower deforestation level and the majority of countries that already used the 10-year length would be worse off by deviating. Thus, there were no clear signs of "gaming" in the choice of reference period length.

The results from reviewing the country submission that use the trend extrapolation method show that all countries have an upwards trend in deforestation, and all use an upwards trend when calculating the FREL/FRL. The incentive to game the system is that a country that uses the trend extrapolation method and has an upward trend in emission will get a higher, and increasing, FREL/FRL compared to using the historical average approach. It certainly looks like gaming is occurring when considering the fact that all the countries have an upwards trend in the FREL/FRL.

In the case of adjustment for national circumstances the incentive is that an upwards adjustment yields a higher FREL/FRL. From the results it certainly looks like gaming is occurring. The countries justify their decision to adjust in various ways, some justifications more valid than others, but the overall picture is that all countries but one (Costa Rica) adjusts their FREL/FRL upwards.

The vagueness and non-intrusive nature of the UNFCCC process and guidelines, combined with the level of country autonomy in setting the FREL/FRL certainly leaves a lot of room for countries to take advantage of the system. The reviewing process and oversight of the country submissions could benefit from a more open process and increased efforts in investigating gaming behavior. It also remains unclear if result-based systems will follow the proposed FRELs/FRLs or whether they will be subject for negotiations between the country and the funders or buyers of carbon credits. There are more areas of the REDD+ program where gaming might occur and if research in these were pursued the overall process might be better from it.

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8 Appendix

Table 17: Reference period results from test group (>10 years)

Higher or lower average deforestation by using submission reference period?	
Lower	**Higher**
Argentina Bangladesh Belize Chile Côte d'Ivoire Ecuador Ethiopia Ghana Honduras Indonesia Kenya Malaysia Mozambique Saint Lucia Togo Uganda Tanzania	Brazil Congo Dominican Republic Guyana Sudan Costa Rica
17 (73.9%)	6 (26.1%)
Malawi Papua New Guinea Solomon Islands Suriname DPR Congo	
22 (78.6)	6 (21.4%)

Table 18: Reference period results from test group (<10 years)

Higher or lower average deforestation by using submission reference period	
Lower	**Higher**
Cambodia Pakistan Paraguay	Equatorial Geuinea Geuinea-Bissau Gabon
3 (50%)	**3** (50%)

Table 19: Reference period results from test group (total)

Higher or lower average deforestation by using submission reference period	
Lower	**Higher**
Argentina Bangladesh Belize Chile Côte d'Ivoire Ecuador Ethiopia Ghana Honduras Indonesia Kenya Malaysia Mozambique Saint Lucia Togo Uganda Tanzania Cambodia Pakistan Paraguay	Brazil Congo Dominican Republic Guyana Sudan Costa Rica Gabon Equatorial Geuinea Geuinea-Bissau
20 (70%)	**9** (30%)
Malawi Papua New Guinea Solomon Islands Suriname DPR Congo	
25 (73.5%)	9 (26.5%)

Table 20: Refernce period results from control group

Higher or lower average deforestation by using submission reference period	
Lower	**Higher**
Guatemala Myanmar	Colombia Guatemala Liberia Madagascar Mexico Myanmar Nicaragua Nigeria Panama Peru Thailand Zambia
2 (14.3%)	**12** (85.7%)
Sri Lanka	Buthan Lao PDR Nepal
3 (16.7%)	**15** (83.3%)

Table 21: Results from trend regression all countries

	Reference period			Trend			
Country	**Start**	**End**	**Duration**	**Trend**	**T-value**	**Direction**	**P>|t|**
Argentina	2002	2013	12	4046	1.34	Up	0.211
Bangladesh	2001	2015	15	551**	2.89	Up	0.013
Belize	2001	2015	15	667**	2.61	Up	0.022
Buthan	2005	2014	10	58	0.97	Up	0.365
Cambodia	2011	2018	8	-10900***	-4.05	Down	0.007
Chile	2001	2013	13	3174**	2.44	Up	0.033
Colombia	2008	2017	10	10760	1	Up	0.344
Congo	2001	2012	12	1067	1.67	Up	0.125
Côte d'Ivoire	2001	2015	15	8024	1.68	Up	0.117
Democratic Republic of the Congo	2001	2014	14	47181**	2.75	Up	0.017
Dominican Republic	2001	2015	15	47	0.21	Up	0.839
Ecuador	2001	2014	14	1392	1.31	Up	0.215
El Salvador	2006	2015	10	-217***	-3.52	Down	0.008
Equatorial Guinea	2014	2018	5	-1831	-1.33	Down	0.275
Ethiopia	2001	2013	13	1981***	3.86	Up	0.003
Gabon	2001	2009	9	531**	3.19	Up	0.015
Ghana	2001	2015	15	3702	1.62	Up	0.13
Guatemala	2007	2016	10	1271	0.19	Up	0.852
Guinea-Bissau	2008	2015	8	2958**	2.7	Up	0.036
Guyana	2001	2012	12	167	1.09	Up	0.301
Honduras	2001	2018	18	4470**	2.57	Up	0.021
Indonesia	2007	2020	14	-23587	-0.95	Down	0.362
Kenya	2003	2018	16	209	0.96	Up	0.354
Lao PDR	2005	2014	10	14851***	4.62	Up	0.002
Liberia	2009	2018	10	21028***	5.83	Up	0
Madagascar	2006	2015	10	27780***	3.51	Up	0.008
Malawi	2006	2016	11	1218**	3.25	Up	0.01
Malaysia	2005	2015	11	16246	1.72	Up	0.119
Mexico	2007	2016	10	1935	0.37	Up	0.722
Mongolia	2006	2015	10	-5188*	-1.92	Down	0.091
Mozambique	2003	2013	11	6060	1.75	Up	0.115
Myanmar	2006	2015	10	22349***	5.98	Up	0
Nepal	2001	2010	10	247	1.8	Up	0.11
Nicaragua	2006	2015	10	-2951	-0.83	Down	0.43
Nigeria	2007	2016	10	8679**	2.6	Up	0.032

Pakistan	2005	2012	8	-129**	-3.18	Down	0.019
Panama	2006	2015	10	-2677***	-3.89	Down	0.005
Papua New Guinea	2001	2013	13	2046**	2.69	Up	0.021
Paraguay	2012	2019	8	-18498	-1.5	Down	0.185
Peru	2010	2019	10	9520	1.83	Up	0.105
Saint Lucia	2001	2013	13	3*	1.94	Up	0.078
Solomon Islands	2001	2017	17	992***	8.07	Up	0
Sri Lanka	2001	2010	10	863**	2.68	Up	0.028
Sudan	2007	2018	12	-19***	-3.59	Down	0.005
Suriname	2001	2019	19	961***	11.38	Up	0
Thailand	2007	2016	10	6521**	2.41	Up	0.043
Togo	2004	2018	15	210*	1.81	Up	0.093
Uganda	2001	2015	15	2728***	4.55	Up	0.001
United Republic of Tanzania	2003	2013	11	14751***	5.55	Up	0
Zambia	2009	2018	10	17026*	2.22	Up	0.057
Outside hansen fitted from 2001							
Brazil	1996	2015	20	-83759**	-2.96	Down	0.011
Burkina Faso	1995	2017	23	-715*	-2.1	Down	0.053
Costa Rica	1997	2009	13	1007	1.6	Up	0.154
Viet Nam	1996	2010	15	12758***	5.84	Up	0
Did not include deforestation							
Dominica	2018	2025	8	-357	-2.4	Down	0.251
India	2001	2008	8	4007**	3.02	Up	0.023

*** significant at the 1% level, ** significant at the 5% level, * significant at 10% level

Source: Submissions dataset and GFC/Hansen data.

Table 22: Total losses and gain in hectares from using submission reference period (test groups)

Lose (in hectares)			
Country	**Submission**	**Test**	**Difference**
Argentina	95 969	105 406	-9 437
Bangladesh	5 943	7 068	-1 125
Belize	11 249	12 778	-1 530
Chile	81 206	86 605	-5 400
Côte d'Ivoire	125 353	141 337	-15 984
Ecuador	43 061	47 695	-4 634
Ethiopia	22 682	25 219	-2 538
Ghana	57 897	63 374	-5 477
Honduras	57 139	72 380	-15 241
Indonesia	1 548 013	1 566 402	-18 389
Kenya	23 511	23 805	-294
Malaysia	460 039	468 501	-8 462
Mozambique	156 208	163 864	-7 656
Saint Lucia	51	61	-9
Togo	2 921	3 295	-374
Uganda	34 004	41 034	-7 029
Tanzania	193 461	198 889	-5 428
Cambodia	174 710	176 372	-1 662
Pakistan	878	887	-10
Paraguay	345 193	366 668	-21 475
total	3 343 518	3 571 641	-228 123
Malawi	15 164	15 780	-617
Papua New Guinea	53 779	57 651	-3 872
Solomon Islands	8 465	11 463	-2 998
Suriname	9 695	14 142	-4 447
DPR Congo	586 858	657 123	-70 265
total	4 113 447	4 327 800	-214 353

Benefits (in hectares)			
Country	**Submission**	**Test**	**Difference**
Brazil	1 402 920	705 788	697 132
Congo	24 674	24 475	199
Dominican Republic	15 224	15 149	75
Guyana	4 075	4 046	29
Sudan	96	83	13
Gabon	16 098	15 556	542
Equatorial Guinea	11 197	8 821	2 376
Guinea-Bissau	14 416	12 857	1 559
total	1 488 700	786 775	701 926

Source: Submissions dataset and GFC/Hansen data.

Table 23: Total losses and gain from using submission reference period (control group)

Lose (in hectares)			
Country	**Submission**	**Test**	**Difference**
El Salvador	3 061	4 080	-1 019
Mongolia	28 631	29 676	-1 046
Sri Lanka	6 810	8 513	-1 703
total	38 502	42 270	-3 767

Benefits (in hectares)			
Country	**Submission**	**Test**	**Difference**
Colombia	228 195	220 396	7 799
Guatemala	82 450	79 207	3 243
Liberia	128 446	94 579	33 866
Madagascar	193 548	158 099	35 450
Mexico	214 266	202 142	12 124
Myanmar	208 510	165 044	43 466
Nicaragua	70 894	64 695	6 199
Nigeria	132 650	105 978	26 672
Panama	22 604	20 265	2 339
Peru	210 153	184 916	25 237
Thailand	124 313	110 530	13 784
Zambia	216 340	175 853	40 487
Buthan	1 222	1 012	210
Lao PDR	145 875	132 881	12 994
Nepal	3 032	2 766	266
total	1 982 499	1 718 363	264 136

Source: Submissions dataset and GFC/Hansen data.

Table 24: FREL/FRL of countries using trend extrapolation

Democratic Republic of Congo		
year	**emissions (tCO2)**	**emission (mtCO2)**
2015	979 151 857	979.15
2016	1 028 693 438	1 028.69
2017	1 078 235 018	1 078.24
2018	1 127 776 598	1 127.78
2019	1 177 318 178	1 177.32
Malawi		
Year	**Emissions (tCO2)**	**emission (mtCO2)**
2017	4 500 682	4.50
2018	4 831 639	4.83
2019	5 162 597	5.16
2020	5 493 554	5.49
2021	5 824 511	5.82
Suriname		
Year	**Emissions (tCO2)**	**emission (mtCO2)**
2020	15 238 428	15.24
2021	15 858 865	15.86
2022	16 479 303	16.48
2023	17 099 741	17.10
2024	17 720 179	17.72
Papua New Guinea		
year	**emissions (tCO2)**	**emission (mtCO2)**
2014	43 369 737	43.37
2015	45 049 344	45.05
2016	46 728 951	46.73
2017	48 408 557	48.41
2018	50 088 164	50.09
Solomon Islands		
year	**emissions (tCO2)**	**emission (mtCO2)**
2018	15 335 717	15.34
2019	16 181 627	16.18
2020	17 027 538	17.03
2021	17 873 448	17.87

Source: Submissions data

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