Achieving The 1.5 °C Goal with Equitable Mitigation in the Latin American Countries

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Abstract

During the past years, the impact of climate change in the Latin America region has become more evident, and is affecting its natural resources and delaying sustainable development. Achieving the 1.5°C long-term temperature goal of the Paris Agreement while ensuring the right to sustainable development, is of particular interest for regions such as Latin America which are highly vulnerable and have a low capacity of adaptation. This article seeks to analyse if the Nationally Determined Contributions (NDCs) submitted within the Paris Agreement framework by the Latin American countries align with achieving the 1.5°C goal.

For this analysis, the cumulative emissions for the 2018–2100 period are distributed among the region and its countries using the climate justice criteria (equality and historical responsibility) outlined in the Model of Climate Justice (MCJ). The results of the MCJ compatible with the 1.5°C global temperature scenario are then compared with the cumulative emissions implied in the NDCs submitted by the Latin American countries.

Two main conclusions are obtained from the NDC analysis. First, the Latin American region, in 2030, will consume 67.8% of the emissions budget allocated by the MCJ until the end of the century. Second, this percentage could be reduced if, firstly, the conditional commitments within the NDC that require foreign aid are achieved, and, secondly, those countries that will consume their entire emissions budget by 2030 submit reviewed NDCs that increase the ambition of their mitigation commitments.

1. Introduction

The Latin American Region (LA), formed by the subregions of Central America (CA) and South America (SA), is particularly vulnerable to the impacts of climate change due to its geographical, sociodemographic and climatic situation (Barcena et al. 2020). Its natural assets make it an extremely diverse region which is sensitive to climate change impacts (IPCC 2014a; Barcena et al. 2020). The region contains the six countries with the most biodiversity in the world; Mexico, Ecuador, Peru, Colombia, Brazil and Venezuela, whilst 40% of the biodiversity of the planet is located in SA (UNEP-WCMC 2016). Anthropogenic activities such as deforestation and land-use changes for urban growth or agricultural and mining activities contribute enormously to the loss of biodiversity in the region and to climate change (IPCC 2014a; Armenteras et al. 2016).

During the last years the impacts of climate change has become evident. According to Barcena et al. (2020), in LA and Caribbean regions, the average temperature observed between 2000 and 2016 is 0.7% higher than the average from 1901–1990. An increase of between 1.6°C and 4°C is estimated for CA and SA by 2100, compared to the average temperature from the 1986–2005 period. Climate change in the region is associated with variations and intensification of natural phenomena such as hurricanes, tropical cyclones, the Niño-Southern Oscillation, the North and South American monsoon system, and the Atlantic Ocean oscillations (IPCC 2014a; Barcena et al. 2020). An increase in sea level from 2 to 7 millimetres in the 1950–2008 period has also been observed, noticeable to a greater extent along the Atlantic coasts (IPCC 2014a), and it is forecasted that the sea level rise will increase by 3.6 millimetres annually between 2040–2070 (Barcena et al. 2020). There was higher annual rainfall in SA, around 0.6 millimetres per day, and a decrease in CA and Chile, around − 1 millimetre per day between 1950 and 2008. In some areas, sea level changes and an increase in precipitation caused floods and disasters with enormous impacts on natural resources and coastal zone ecosystems such as mangroves, corals, and fisheries, causing socioeconomic impacts along the coast (IPCC 2014a; Reyer et al. 2017; Barcena et

al. 2020). In addition to these impacts, there are also socioeconomic impacts due to the scarcity of rainfall. According to the Economic Commission for Latin America and the Caribbean (ECLAC), migration and drought are correlated. One example is the migration from CA, especially from the northern corridor that extends from Guatemala to Honduras, where drought has worsened due to climate change. There are estimates of potential migratory flow, for example, in a worst-case scenario estimation, by 2050 in LA, between 3.9 and 17 million people will be climatic migrants (Kumari Rigaud et al. 2018; Barcena et al. 2020).

In the last years, the socioeconomic condition of countries in LA has improved. However, the region still has challenges to meet, including facing climate change without leaving its development needs behind. Historically the region has been characterized by slow economic growth, structural weakness and income inequality (Barcena et al. 2020). Regional structural weaknesses include, among others, precarious health systems, high labour informality and poverty (International Monetary Fund 2020; ECLAC 2021).

The average annual economic growth between 2014 and 2019 in LA was 0.3% (ECLAC 2021). As per the income classification from the World Bank (WB) for the Latin American countries, Chile and Uruguay are high-income countries. Bolivia, El Salvador, Guatemala, Honduras and Nicaragua are lower-middle-income countries. The rest of the countries are upper-middle countries, namely Argentina, Belize, Brazil, Colombia, Costa Rica, Ecuador, Guyana, Mexico, Panama, Paraguay, Peru, Suriname, and Venezuela. According to the World Bank, LA is not among the poorest regions of the world although its extreme poverty levels are below those of the Middle East and North Africa. However, in LA (including the Caribbean), the population living at the poverty line of US$3.20 a day during 2018 totalled 9.3%, around 59.4 million; while 3.8%, around 24.2 million, were at the extreme poverty level of US$1.90 a day (World Bank 2020). Furthermore, the region is characterized as having a high degree of social inequality (UNDP 2019). These inequalities cause delays in the eradication of poverty and unequal access to drinking water, sanitation and adequate housing; at the same time, these factors are associated with the population's vulnerability and low capacity to adapt to climate change (IPCC 2014b).

When tackling the climatic crisis in LA, it is necessary to have cooperation and political will backed by sufficient and relevant information that can help to generate tools and establish policies for climate change mitigation that also contemplate sustainable development needs. In the context of regional cooperation, the ECLAC promotes cooperation programs between the region's countries to generate knowledge and design public policies that encourage inclusive and sustainable adaptation to climate change and a transition to low greenhouse-gasses-emitting economies. In the context of international cooperation, the outcomes from the Summits of Latin America, the Caribbean, and the European Union (EULAC) are especially relevant, particularly the Lima Declaration "Addressing our peoples' priorities together" approved during the fifth summit that took place in 2008. The Lima Declaration established as one of its main objectives, the compromise to push for bi-regional cooperation on climate change by facilitating mitigation and adaptation initiatives in line with sustainable development and supported by technology, financing, and capacity building (EULAC 2008). At the heart of this cooperation framework between LA and UE27, the Euroclima program was born. This UE27 program financed by the Development Cooperation Instrument (DCI) promotes projects that focus on achieving the Lima Declaration's objective (CEPAL 2021).

The countries of LA have shown firm willingness to fight against the climate emergency and have submitted their first commitments within the Paris Agreement (PA) framework. The PA is the international treaty that governs the multilateral climate change policy from 2020 onwards. The agreement establishes the goal to

maintain the average temperature increase well below 2°C and to pursue efforts to limit it to 1.5°C with respect to preindustrial levels. The PA also establishes that efforts for climate change mitigation should be based on equity and the “common, but differentiated responsibilities and respective capabilities in the light of different national circumstances” (CBDR&RC) that emanates from the United Nations Framework Convention on Climate Change (UNFCCC). Developing countries, such as Latin American ones, should continue enhancing their mitigation efforts and are encouraged to gradually move towards economy-wide emission reduction or limitation targets in the light of different national circumstances. (United Nations 1992, 2015).

The Nationally Determined Contributions (NDC) are an essential part of the bottom-up strategy of the PA to achieve the temperature goal mentioned before. Every five years, in their NDC, countries should establish the mitigation commitments that will achieve the long-term temperature goals established in the agreement. According to the PA’s article 4, the successive NDCs have to reflect the highest possible level of ambition of every country reflecting their CBDR-RC principle (United Nations 2015). The Paris Rulebook, approved during COP24 in 2018, contains the guidelines that the NDCs should follow to provide the necessary information to ensure their clarity, transparency and comprehension. (4/CMA.1 UNFCCC 2018).

The COP21 (1/CP.21) Paris decisions in 2015 already highlighted the concern that the aggregated effect of the commitments did not fit within the range of the least-cost 2 °C scenarios. Consequently, decisions 23 and 24 urged the PA Parties to update their NDC in 2020 (UNFCCC 2015). Due to the COVID-19 pandemic, this updating process has not been completed and is assumed to have been extended until the start of the COP26, scheduled for November 2021. Because of this, the result of the Synthesis Report published by the UNFCCC Secretariat on February 26th, 2021, is especially relevant. The report assesses the aggregated effect of the 48 NDCs updated at the end of 2020, which represent 75 Parties responsible for 30% of greenhouse gasses (GHG) emission. The report confirms that the aggregated effect of these NDCs only increases the emissions reduction expected for 2030 by 2.8% compared to their previous versions. Likewise, it remarks that these NDCs will only achieve a reduction of 0.5% of the emissions in 2030 compared to the values of 2010. Moreover, the report also highlights that according to the SR1.5, in order not to exceed the 1.5°C threshold, the anthropogenic CO_2 net emissions should decrease approximately 45% by 2030 compared to the level of 2010 (UNFCCC 2021).

Considering the gap between the current NDCs and the long-term temperature goal of the PA, the authors considered it urgent to propose an analysis that could ensure the development of strategies to increase the NDCs ambition in order to close this gap. For example, an analysis of geographic regions integrated by countries willing to cooperate could implement joint mitigation strategies that go beyond individual actions (Alcaraz et al. 2021). Considering the political willingness of the LA region, demonstrated during the last years in response to the climate crisis and the development needs of the region, the analysis of the LA countries’ current NDCs under the climate justice prism is considered of particular interest for the policymakers. Although there are studies that carry out equitable emissions allocations considering one or a few Latin-American countries with high emissions and their NDC compatibility in achieving the PA long term goals (CAT; Climate and Energy College; UNEP; Climate Change Authority 2014; Pan et al. 2017; Robiou Du Pont et al. 2017), there is an important lack of studies that consider the majority of CA and SA countries and integrate a regional analysis that includes such components. The analysis presented in this article aims to discover if the NDCs presented by the countries of LA are fair and ambitious in a mitigation scenario compatible with the 1.5°C global temperature goal. For this analysis, the Model of Climate Justice (MCJ) Alcaraz et al. (2018) will be used. The MCJ applies

equality and historical responsibility criteria to distribute the cumulative emissions that could be released to the atmosphere in a future compatible with the 1.5°C global goal. In other words, the MCJ allows us to determine the emissions budget that would be available for each country and for LA as a regional country group. Once the emissions budget is determined, the share of this budget that the first NDC submitted by the LA countries will consume is analysed, and valuations based on their current circumstances and their developmental needs can be made.

Starting from the above description, this article is structured as follows: In Sect. 2, the methodology and the data used for the analysis will be described. Subsequently, in Sect. 3, the results of the analysis will be presented and discussed. Finally, in Sect. 4, the conclusions based on the analysis of the LA countries will be presented.

2. Methodology

2.1 Studied countries

This article will study the 21 countries of LA. The historical GHG emissions data is obtained from the PRIMAP-hist dataset, excluding emissions from Land Use, Land Use Change, and Forestry (LULUCF) and constructed from the information reported by the UNFCCC Parties (Gütschow et al. 2019). It is important to comment that in the case of Bolivia, the emissions data from hydrofluorocarbons (HFCs) gases is abnormally high. This anomaly first appeared in data reported in the Second National Communication of Bolivia submitted in 2009 and was maintained in the Third National Communication submitted in 2020. To put this in context it must be considered that, when looking at CO_2, Bolivia's emissions represent 0.5% of the global emissions; but HFCs emissions, if the reported values are correct, would represent 5% of the global emissions. Given the uncertainty these numbers cause, the authors have opted to exclude fluorinated gases from the study of Bolivia.

Table 1 shows a selection of indicators related to the total emissions profile of every country. Although it is a region with many similarities, significant differences between countries can be observed. It is important to highlight that Bolivia, El Salvador, Honduras, and Nicaragua, the four countries in the region that are classified as lower-middle-income, have emissions, GDP, and energy consumption per capita that are considerably lower than the rest.

For the group of countries studied, the majority of indicators are below the world average. Only Argentina, Paraguay, Uruguay, and Venezuela have emissions per capita values higher than the world average. In the cases of Uruguay and Paraguay, these higher emissions per capita are caused by the non-CO_2 emissions from the agriculture sector. It is also important to highlight that the two largest emitters from this region, Brazil, and Mexico, have emissions per capita below the word average.

Table 2 brings together development indicators that help to give a more comprehensive picture of the region and supplement the emissions profile described previously. It becomes evident that some countries of the region have yet to answer their development needs. The following cases should be highlighted: El Salvador, Guatemala, Guyana, Honduras have a Human Development Index (HDI) below 0.7; and Belize, Guyana, Honduras, Suriname, and Venezuela where more than 10% of the population have less than US$1.90 a day. Similarly, it is important to notice that there are countries in the region where more than 10% of their population are without access to electricity or drinking water.

2.2 The Model of Climate Justice

In this study, the Model of Climate Justice (MCJ) is used to distribute the GHG cumulative emissions for the 2018–2100 period for each of the countries studied (Alcaraz et al. 2018). This distribution is compatible with a global emission scenario that limits the temperature increase to 1.5°C with respect to preindustrial temperature. The global scenario considered is that of the RCP1.9 IMAGE 3.0.1 SSP1-19 for Kyoto Gases (excluding CO_2 from Land Uses) from IIASA (van Vuuren et al. 2017; IIASA and IAMC 2019). Additionally, to calculate the MCJ, the GHG historical emissions data obtained from the PRIMAP-hist dataset (Gütschow et al. 2019) are used as well as the historical population data and future projections taken from the UNDESA medium variant scenario (UNDESA 2019).

The MCJ distributes the future GHG emissions for the 2018–2100 period using equality and historical responsibility criteria, both recognized by the Fifth Assessment Report (AR5) as dimensions of equity (IPCC 2014c). It allocates the same level of emissions per capita for all countries and then applies a correction based on the historical responsibility of each one of them. Thus, the MCJ allocates more emissions to countries with emissions per capita below the world average in the considered historical period and vice versa. For further insights into the mathematical details of the MCJ, the authors recommend reading Annex I contained in the supplementary electronic material of the O. Alcaraz et al. (2018) paper.

The period of historical responsibility applied by the MCJ has been established as starting from 1994. The year in which to start accounting historical responsibility is much debated and there is no clear consensus (Müller et al. 2009; Rocha et al. 2015). The year selected for this study is 1994, the year in which the UNFCCC entered into force after its ratification process.

The results obtained by applying the MCJ are the emissions for the period 2018–2100 that could be allocated to the countries of LA according to equity criteria. This is the emissions budget to be consumed between 2018 and 2100. Once this budget is assigned, it is compared to the cumulative emissions estimate for the 2018–2030 period implied by the NDC of each country.

2.3 The NDCs

In this analysis, the latest version of the NDC submitted by every country up until January 2021 is considered. This includes the updates that some countries have made during 2020 (UNFCCC). By December 31st, 2020, ten LA countries had complied with the provisions of article 24 of the PA's decisions and had presented an update of their NDC in 2020. It is expected that during 2021 and before COP26, the countries that had not updated their NDC will do so (UNFCCC 2015).

Table 3 shows a summary of the mitigation objectives and information presented in the Latin American NDCs. Both unconditional and conditional objectives (subject to external aid) are displayed. It's worth noting that the majority of countries presented a mitigation commitment for all the GHG. This is the reason why cumulative GHG emissions are used in this study (Meinshausen et al. 2009; Alcaraz et al. 2019).

Determining the cumulative emissions for the period 2018–2030 that the NDC of each country implies, requires previously knowing the estimated value of their emissions level in 2030. Due to the uncertainty some NDCs present, it has also been decided to include estimations from three external sources: Climate Action Tracker,

Climate Energy College and UNEP (CAT; Climate and Energy College; UNEP). When preparing this paper, some of the external sources had not updated their emission projections for those countries that had submitted a new NDC in December 2020 (i.e. Argentina, Colombia, Costa Rica, Mexico, Nicaragua, Panama and Peru), so only updated estimations are considered.

It should be noted that, unlike other countries, the new version of Chile's NDC presents both a commitment based on cumulative emissions for the 2020–2030 period as well as a reduction target to be achieved by 2030. In addition to presenting an absolute target for 2030, Costa Rica has also made a commitment with regard to their cumulative emissions between 2021 and 2030. The authors consider this type of commitment more robust than those that are based on a target year since it offers information about the overall emissions the country predicts will be released into the atmosphere during a specific period. Therefore the increase in temperature that such emissions will produce can be estimated with greater certainty (Matthews et al. 2020).

The authors' method of calculating the resulting emissions for 2030 from each NDC depends on the country's type of commitment.

- For those countries that present a target as a percentage reduction from a base year, 2030 emissions are calculated by applying the reduction directly to the historical emissions data from the base year. In the specific case of Brazil, due to abnormally high emission levels from the LULUCF sector in the base year and also the fact that the historical data used does not include LULUCF, the projection made by the authors has not been taken into account, and only the one from external sources is considered.
- For those countries with an absolute emission reduction target, an emission reduction is determined based on the historical emissions data presented in the NDC and is applied to the historical emissions from the PRIMAP-hist Dataset. Note that this may lead to a value of emissions in 2030 that is different from the one presented as a target in the NDC. In the case of Chile, despite it presenting its target in cumulative emissions, the calculations have also been done in this way since Chile presents a secondary objective of this type.
- For those countries with a target based on a business as usual (BAU) scenario, the BAU scenario presented in the NDC is transferred to the historical PRIMAP-hist Dataset. The reduction target in the NDC is applied to the year 2030 of this scenario. For the cases of El Salvador and Venezuela that present a target of this kind, but whose NDC only refers to CO_2 emissions instead of all the GHG, the method described above for disaggregated CO_2 emissions is used, and for GHG, a trend scenario like the one described in the next point is calculated.
- For those cases in which the NDC does not present a quantifiable emissions reduction target, a linear trend scenario is calculated based on the historical data.
- For Uruguay, the only studied country that presents a target based on emission intensity and that also presents a different target for each GHG, an estimate of reduction with respect to the base year presented in the same NDC is used.

Once the emissions from each country for 2030 has been estimated, a linear trajectory between 2017 (last year of historical data) and 2030 is assumed. By adding up all the emissions between 2018 and 2030, the cumulative emissions for each country for this period are determined. For countries using an emissions reduction target for 2025 instead of 2030, the value of emissions resulting for 2025 is calculated according to

the method corresponding to its objective type, and then the linear trend between 2017 and 2025 is continued in order to determine the emissions in 2030.

This procedure is also carried out with the emission estimations from external sources for the year 2030. In those countries with more than one estimation, the cumulative emission value used for the analysis is determined by calculating the average of the values from all the available sources.

3. Results And Discussion

3.1 Cumulative emissions allocated by the MCJ to LA countries.

Figure 1 shows the calculations, for the countries of the LA region, of both the historical cumulative emissions for the period 1994–2017 and the future cumulative emissions allocated under climate justice criteria by the MCJ during the period 2018–2100 and compatible with the RCP 1.9 global mitigation scenario.

The MCJ allocates a total of 65.43 $GtCO_{2eq}$ to the group of LA countries for the period 2018–2100 (see Fig. 1). This is a similar percentage (1.80% higher) to the amount that the LA group emitted during the historical period analysed (1994–2017). These numbers may give the false impression that the 1.5°C target does not imply severe emissions reduction for LA. For this reason, it is important to underline that the aforementioned 65.43 $GtCO_{2eq}$ constitutes the cumulative emissions budget that will be available for the next 83 years (2018–2100), whilst practically the same amount (64.28 $GtCO_{2eq}$) has been emitted during a historical period of only 24 years (1994–2017). In other words, calculating a rough average, annual emissions for the future period would be 0.79 $GtCO_{2eq}$/year, while those of the historical period analysed amounted to 2.7 $GtCO_{2eq}$/year.

Worldwide the situation is not equal; the RCP 1.9 scenario requires that the world addresses the period 2018–2100 with a cumulative emissions reduction of 15.3% compared to the emissions during the historical period 1994–2017. The reason why the efforts required of the LA group are less is due to its low historical responsibility and the fact that when the MCJ allocates future emission, it compensates countries with a historical responsibility that is below the world average. The emissions per capita from the LA group during 1994–2017 were 5.16 tCO_{2eq}, 14.6% lower than world emissions of 6.04 tCO_{2eq} per capita. (Table 1). It is important to highlight that even the region's "high-income" group has a historical responsibility per capita lower than the world average.

Figure 1 also compares the historical cumulative emissions with the cumulative emissions allocated by the MCJ for every LA country. Here significant differences can be appreciated depending on the country. Considering that worldwide, to achieve the 1.5°C target, it is essential that the cumulative emissions for the period 2018–2100 be 15.3% lower than the emissions during the historical period 1994–2017, we will take this value as a reference when assessing the mitigation efforts that the countries should make, based on climate justice criteria. Within LA, three groups can be identified:

- Countries with a future cumulative emissions allocation that is more than 15.3% lower than the historical cumulative: Argentina, Paraguay, Uruguay, and Venezuela. All of them had historical emissions per capita above the world and LA average, and therefore their future mitigation efforts should be higher than the global average.

- Argentina, Paraguay, and Uruguay have economies that are highly focused on the production of agricultural products for export. The weight of the agriculture sector emissions (mainly CH_4 and N_2O) with respect to the total GHG is very important, representing 76% and 78% in the cases of Uruguay and Paraguay, respectively (Gütschow et al. 2021). The fact that CH_4 and N_2O remain in the atmosphere for relatively less time than CO_2, could lead us to question the methodology, based on assessments of cumulative emissions, that was used, especially in Uruguay and Paraguay.
- It should be noted that Argentina and Uruguay have good results in their development indicators, and at the same time, among the countries of the region, they have lower levels of inequality, as reflected by the Gini coefficient (see Table 2).
- Venezuela deserves a separate comment. It is the country with the highest energy intensity in the region. 94% of the country's emissions come from the energy sector and they are closely related to oil extraction (Gütschow et al. 2021). In 2013, fuel exports constituted 98% of the country's total exports, contributing to 24% of their GDP (ECLAC; World Bank). This country still has major challenges in reducing poverty rates.
- Countries that, according to climate justice criteria, should face the future with an emissions budget lower than the emissions they released during the 1994–2017 period, but whose reduction effort can be below the world average (below 15.3%), namely Chile, Mexico, and Suriname. The per capita emissions of these three countries are above the LA average but below the world average. Mexico is the country with the second highest carbon intensity in the region, after Venezuela. 70% of this country's emissions come from energy generation (Gütschow et al. 2021), with more than 80% based on fossil fuels, mainly oil and natural gas (SENER 2020).

In terms of development and economic growth in this group, Chile stands out with the highest GDP per capita and HDI score of the region and is the second highest of the LA countries group with less of its population in extreme poverty. Contrary to the case of Chile, Suriname is the country that presents more challenges in terms of poverty and inequality; its population ratio with incomes below the US$1.90 per day threshold and Gini index are the highest of LA (see Table 2)

- Countries that will face the future with aggregate emissions similar to those of the historical period; Brazil is the only country in this group. Its per capita emissions are below the world average and slightly above the Latin American average. It is the most populated country in the region, and although its HDI and population ratio in extreme poverty are below the world and the Latin American averages, it is the second highest country with the biggest inequalities, like Belize, with a 53.3 Gini coefficient (Table 2).
- Countries that could face the future with an emissions budget for the period 2018–2100 higher than the cumulative emissions released in 1994–2017. In this group, there are 12 of the 21 analysed countries:
- Those with an allocated increase of between 3.5% and 100%: Bolivia, Colombia, Costa Rica, Ecuador, Guyana, Panama, and Peru. All of them have historical cumulative emissions per capita below the Latin American and world averages. Guyana is the country with the highest energy intensity in the region. Within the group, Guyana has the highest poverty ratio and lowest HDI. Panama has the second highest GDP per capita in the region, and Colombia and Costa Rica, among those with the highest levels of inequality. Bolivia, Ecuador, and Peru have relatively high percentages of the population without access to drinking water. Bolivia and Guyana are the countries with the lowest percentage of access to electricity (Table 2).

- Those with an allocated increase of 100%: Guatemala, Honduras, El Salvador, Nicaragua y Belize. This group of countries have cumulative emissions per capita far below the LA and world averages. In this group, there are three of the lower-middle-income countries of Central America. All of the countries in this group have the lowest HDI scores of the region, positioned below the world and LA averages. Honduras has the lowest GDP per capita and HDI of the region and after Suriname is the third highest country in the Gini Index. These countries still have challenges in accessing basic resources such as electricity and drinking water. The electricity coverage of Honduras only reaches 77% of the population, the lowest percentage of all LA. While in Nicaragua, the percentage of the population without drinking water access exceeds 80%, being the highest in LA.

3.2 Analysis of the Latin American NDCs

In this section, the implied cumulative emissions of the 2030 commitments established by the LA countries in their last NDC are analysed. These cumulative emissions are compared with the total emission budget (or cumulative emissions) allocated by the MCJ for the 2018–2100 period in line with the 1.5°C global temperature goal (Fig. 2).

When the aggregate effect of the unconditional commitments presented by LA countries is analysed and compared with the emissions budget allocated by the MCJ, it is observed that by the year 2030, the region will have consumed 67.8% of the total emissions assigned until the end of the century. In contrast, this percentage decreases to 64.7% when the conditional commitments are considered (Fig. 2). Although high, these percentages are lower than those of other regions studied, such as the group of Mediterranean countries (Alcaraz et al. 2021). So the group of LA countries could still be in alignment with the long-term temperature goal of 1.5°C. In order to move the LA region group towards the 1.5°C goal, it should first be assured that those countries that have made conditional commitments receive the foreign aid needed to achieve them. Secondly, it is necessary to promote mechanisms for cooperation around climate action and access to financial and low-GHG-emissions technologies for the region's countries.

With this in mind, the report by the Climate Finance Group of Latin America and the Caribean (GFLAC) assesses the extent to which the income received by countries from bilateral and multilateral sources and public budgets include portions destined for the mitigation of and adaptation to climate change. The report highlights that, in general, there is no evaluation of the costs of implementing the NDCs, which makes it very difficult to determine to what extent the current financial flows are adequate (GFLAC 2021).

When the accumulated consumption of emissions by 2030 is analysed for each Income Group of the region, a significant difference is observed between the lower-middle-income countries and the other countries with higher income levels. Whilst the group of lower-middle-income countries will only consume 31.1% of the emissions budget assigned by the MCJ, the upper-middle and high-income countries will consume 70.2% and 76.8% respectively. This could lead to the idea that the budget allocated for the lower-middle-income is over-exaggerated. However it should be remembered that these countries have the greatest development challenges in the region. Additionally, they are classified as countries with a high index of climate risk which implies that they must make a great effort to adapt to the impacts of climate change that they are already suffering from (Eckstein et al. 2021). As a result, they are likely to need and to use the emission budget during the next decades.

Figure 2 also shows the percentage of the emissions budget that will be consumed by every country based on the commitments contained in their first NDC, and here significant differences between them are observed:

- By 2030, Argentina, Uruguay, Paraguay, and Venezuela will have consumed more than the total emissions assigned by the MCJ under climate justice criteria. Although, and as mentioned in the previous section, the emissions budget that the MCJ allocates to Paraguay and Uruguay could be underestimated, all these countries would have to considerably increase the ambition of their NDC in order to be in line with the 1.5°C global temperature goal. Except for Argentina, the rest have made conditional commitments to increase the ambition of their current NDC that, if achieved, would significantly reduce their emissions by 2030.
- Bolivia, Brazil, Chile, Ecuador, Guyana, Mexico, Panama, Peru, and Suriname will have consumed between 40% and 100% of their cumulative emissions. These countries could establish more ambitious NDCs in line with the 1.5°C goal and the sustainable development of their population. Three of these countries propose conditional commitments within their current NDC that require foreign aid to increase their ambition.
- Belize, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua will have consumed less than 40% of the cumulative emissions allocated by the MCJ in 2030. According to the MCJ results, this group of countries would be able to count on around 60% of their allocated emissions after 2030 and could try to use this carbon space to ensure their population's economic growth and development. The following subsection will address this item in detail. In addition, El Salvador, Guatemala, and Honduras have established conditional commitments that could be met with multilateral aid as expressed in their NDC.

3.3 Analysis of the emissions and economic evolution for Latin America

Figure X compares the evolution of the GHG emissions per capita as a function of their GDP per capita for LA and the world. It is worth noting the difference between the world per capita emissions and those of LA, and the slower growth rate of GDP per capita in LA compared to the world average. Whilst at a world level, during the last decade, there has been a tendency to decouple economic growth and emissions, this trend is not yet implied in the LA curve, which has a clearly positive slope. Achieving this decoupling is key to building development trajectories compatible with the ambitious 1.5°C goal. Some recommendations to achieve this are: promoting technological innovations and energy efficiency that would help reduce energy intensity; implementing renewable energy technologies that would reduce carbon intensity; and promoting low-emissions lifestyles by increasing public awareness around energy and emissions savings (Chen et al. 2018).

Considering that there are countries in the region with pending development challenges, a major challenge for LA is to achieve a low-emissions economic growth. This growth should be framed within a model of sustainable development that places human dignity and environmental integrity as the ultimate goals of development policies. To achieve this, the LA region should work on two key tasks:

a) On the one hand, LA must be able to mobilize climate financing. Regarding this, it is important to mention that the most recent work, available since 2018, from the UNFCCC Standing Committee on Finance indicates that LA and the Caribbean received, in 2015–2016, 22% of the global funding coming from Multilateral Climate Funds (MCF), 17% of the funding from Multilateral Development Banks (MDBs); and 10% of bilateral climate financing reported by the OECD countries (UNFCCC Standing Committee on Finance 2018).

b) On the other hand, LA should work on the unavoidable task of complying with the objective 2.1.c of the PA and place the financial flows at a level that permits development strategies that are climate-resilient and low in emissions. In this regard, a first noteworthy effort in the LA region is the work of GFLAC: “the Sustainable Finance Index”. This report seeks to “monitor the national and international incomes and expenditures available in developing countries to attend the climate change problem and the sustainable development objectives associated with it. Furthermore, it aims to discover those activities that could be hindering this progress, such as activities associated with fossil fuel extraction and production, the main emitters of GEI in the world” (GFLAC 2021).
The lower-left section of Fig. 3 shows the remaining cumulative emissions, based on climate justice criteria, that would be available after 2030 for the LA group if the unconditional commitments of their NDCs are met. As observed throughout this study, the region’s countries have individual heterogeneous emissions characteristics and socioeconomic and development needs. For this reason, these countries would need to use their allocated cumulative emissions budget to ensure their population’s rights to sustainable development with particular attention to basic needs such as access to drinking water, sanitation, education, nutrition, and housing as well as reducing poverty rates and assuring equal access to resources. (Rao and Baer 2012).

Properly managing the emissions budget that would still remain for the region based on climate justice criteria implies developing long-term policies. Regarding this, at the end of 2020, only two LA countries, Costa Rica and Mexico, had sent their long-term low greenhouse gas emission development strategies in accordance with Article 4, paragraph 19, of the Paris Agreement and decision 1/CP21 paragraph 35, inviting Parties to communicate their strategies to the secretariat by 2020 (UNFCCC). Therefore, it is still necessary for the rest of the region’s countries to develop such strategies, which should define and program the profound structural changes required to place the region on the path towards the long-term PA goal. During the 2020 Clime Ambition Summit, Argentina announced its willingness to develop strategies and commit to carbon neutrality by 2050 (UN et al.).

4. Conclusions

Latin America faces the tremendous challenge of advancing along the path of sustainable development, whilst overcoming the structural conditions that make it one of the regions of the planet with the most inequality. In addition, it needs to face the impacts of climate change caused by its high levels of vulnerability and promote climate resilience for its populations. All of this while attending to the commitments acquired within the Paris Agreement framework and contributing to achieving the goal to stabilize the increase in global average temperature at 1.5°C. This contribution, according to the PA, should be made based on equity and whilst promoting transparency and environmental integrity (United Nations 2015).

The scientific community is warning that the scenario of stabilizing the average temperature at 1.5°C is highly ambitious for all the countries of the planet together and requires drastic reductions of emissions of around 7.6% annually, at a global level (IPCC 2018; Höhne et al. 2020). Although energy sector emissions dropped in 2020 due to the COVID-19 pandemic, a rebound is expected during 2021 caused by the post-COVID-19 economic recovery (IEA 2021). Therefore, it seems that the world is still far from achieving the 1.5°C goal.

In this context, it is important that the decision-makers of developing countries can count on analyses that assess the mitigation goals under the prism of climate justice in order to put on the table the arguments and

strategies that permit align the countries' policies with the PA's global goals. The analysis presented here has been made based on the emissions budgets. The authors believe that this is one way to strengthen transparency and promote environmental integrity. Formulating the mitigation goals using the logic of emissions budgets by estimating the GHG cumulative emissions that an NDC would produce throughout its implementation period will contribute to reducing the uncertainty concerning the real figures of aggregated emission of all NDCs. Moreover, it also allows many developing countries, such as those of LA, to quantitively support their ambition arguments based on equity and CBDR&RC principle, given the increasingly limited capacity of the atmosphere to host GHG without exceeding the agreed temperature goal.

From the analysis of the cumulative emissions distribution obtained with the MCJ for the period 2018–2100, it can be deduced that the Latin American region could face the future with a similar emissions budget. Specifically, 1.80% higher than that released throughout the historical period considered (1994–2017) because the historical responsibility of the countries in LA, estimated in terms of the cumulative emissions per capita, is below the world average.

Similarly, based on the MCJ and focusing on each of the region's countries, it is observed that there are four countries (Argentina, Paraguay, Uruguay, and Venezuela) that should face their future with a reduction in their emissions budget (2018–2100) with respect to their historical emissions (1994–2017), that is higher than the average world reduction; i.e higher than 15.3%. Under the same prism, it is observed that three countries (Chile, Mexico, and Suriname) could reduce their future emissions at a lower level than the world average whilst the rest could face the future with an equal emissions budget (Brazil) or one that is higher than their historical emissions (1994–2017).

With regard to the consumption of the emissions budgets the NDCs submitted by LA countries imply, it is concluded that in 2030 the region as a whole will have consumed 67.8% of the emissions budget allocated by the MCJ until the end of the century. This percentage is relatively high and could be reduced to 64.7% if the foreign aid conditioned commitments are achieved. It could also be reduced if, throughout 2021, countries review their NDC in order to increase the ambition of their mitigation commitments, especially those countries that by 2030, according to this analysis, will have consumed more than the entire budget assigned for them under climate justice criteria (Argentina, Paraguay, Uruguay, and Venezuela). This will allow the region to be on the way to achieving the global temperature goal of the Paris Agreement.

The differences between the group of countries based on their income level are also noteworthy. The four lower-middle-income countries of the region, Bolivia, El Salvador, Honduras, and Nicaragua, share historical emissions per capita lower than the world average. Therefore, based on climate justice criteria, they can have future cumulative emissions (2018–2100) above their historical cumulative values (1994–2017). The NDC aggregate for these countries, with an approximate 30% consumption of their emissions budget is more aligned with the 1.5°C goal. Considering that these countries include those with higher poverty rates and lack of basic resources of the LA region, their remaining emissions budget should give them some breathing-room and allow them to address some of their remaining development challenges and gradually advance towards a low-emissions economy.

Beyond the analysis presented in this article, the authors argue that the logic of the emissions budget should be intrinsic to the NDC. From the perspective of environmental integrity, it is from the assessment of cumulative

emissions during the implementation period of every NDC that the contribution to the increase of the temperature goal can be estimated (Matthews et al. 2020). Thus, in the effort towards a strengthened, transparent, and more ambitious implementation of the Paris Agreement, it is key for countries to be able to set their mitigation goals by quantifying the emissions budget they will use. Such quantification will allow developing countries to declare the atmosphere space they consider their fair share and so guarantee the right to sustainable development and achievement of human rights. In addition, at a world level, it will allow for the monitoring of the consumption of the remaining global emissions budget that is compatible with the 1.5°C goal, and, when the budget runs out, to make evident the enormous responsibility that will be put onto the future generations, a fact that constitutes a severe challenge for intergenerational equity.

Last but not least, the global health crisis caused by COVID-19 requires the genesis of national agreements that take advantage of the current window of opportunity to promote systemic transformations that will enable the world to face the climate challenge, in line with what the IPCC has been warning for many years. In this sense, it is fundamental to realise that these systemic transformations require a new political and economic ethos, because, since the beginning of the industrial revolution, there has been an increase of the GHG concentration in the atmosphere that has no historical precedents. This increase constitutes a severe threat to the viability of terrestrial ecosystems and the future of humanity (Guterres 2020). LA should make efforts to take advantage of this window of opportunity by legitimizing its low historical responsibility for the climate emergency and initiating a sustainable development that allows it to address damaging inequalities.

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Tables

Table 1
Indicators from Latin American countries, Latin American total, and subgroups by income level and World aggregate. Population data from UNDESA (UNDESA 2019), emissions from PRIMAP-hist. dataset (Gütschow et al. 2019), GDP from World Bank (World Bank), and TPES from the International Energy Agency (IEA).

	Population (2017)	Cumulative GHG em. per capita (1994–2017)	GHG em. per capita (2017)	GDP (PPP) per capita (2017)	TPES per capita (2017)	Energy intensity (2017)	Carbon intensity (2017)
	Millions	tCO_{2eq}	tCO_{2eq}	USD_{2011}	$\cdot 10^{-3}$ toe	$\cdot 10^{-6}$ toe/USD_{2011}	tCO_2/toe
Argentina	43.9	8.03	7.92	18992	1838	97	2.5
Belize	0.4	2.86	3.06	7592	1015	134	1.7
Bolivia	11.2	3.23*	3.63*	6799	796	117	2.0
Brazil	207.8	4.95	5.39	14236	1494	105	1.6
Chile	18.5	5.31	6.01	22297	2095	94	2.2
Colombia	48.9	3.17	3.41	13184	818	62	2.1
Costa Rica	4.9	3.23	3.52	15430	1000	65	1.8
Ecuador	16.8	4.06	3.85	10454	878	84	2.6
El Salvador	6.4	1.86	2.00	7247	653	90	2.1
Guatemala	16.9	1.87	2.02	7423	746	101	1.3
Guyana	0.8	4.49	5.22	7401	1136	153	2.5
Honduras	9.4	1.98	2.13	4469	661	148	1.7
Mexico	124.8	5.80	5.95	17956	1457	81	3.0
Nicaragua	6.4	2.57	2.88	5169	633	122	1.5
Panama	4.1	3.51	3.80	22244	1160	52	2.3
Paraguay	6.9	6.74	8.11	11790	995	84	1.0
Peru	31.4	2.99	3.53	12517	736	59	2.9
Suriname	0.6	5.96	6.06	13636	1686	124	2.6
Uruguay	3.4	10.63	10.74	20659	1516	73	1.7
Venezuela	29.4	9.81	8.67	11485	1561	136	3.7
Latin America	**593.0**	**5.16**	**5.36**	**14598**	**1342**	**92**	**2.3**

Note: Emissions data does not include LULUCF. *Bolivia historical emissions data does not include HFC-gases.

	Population (2017)	Cumulative GHG em. per capita (1994–2017)	GHG em. per capita (2017)	GDP (PPP) per capita (2017)	TPES per capita (2017)	Energy intensity (2017)	Carbon intensity (2017)
High-income	26.0	5.82	6.29	22072	1871	85	2.2
Upper-middle-income	533.5	5.29	5.48	14778	1356	92	2.3
Lower-middle-income	33.4	2.48	2.75	5915	699	118	1.8
World	7550	6.04	6.30	15463	1851	120	2.5

Note: Emissions data does not include LULUCF. *Bolivia historical emissions data does not include HFC-gases.

Table 2
Latin American countries' development indicators. Poverty headcount ratio at $1.90 a day, Gini Index and People using drinking water services from World Bank (World Bank DataBank | The World Bank 2020); Human Development Index from (UNEP 2020); Electricity Coverage from (OLADE 2020).

	Poverty headcount ratio at $1.90 a day (2011 PPP) (2017*)	**Human Development Index (2017)**	**Gini Index (World Bank estimate) (2017)**	**Electricity Coverage (2017)**	**People using at least basic drinking water services (2017**)**
	(% of population)			**(% of population)**	**(% of population)**
Argentina	0.80	0.84	41.2	100	99.1
Belize	13.90	0.71	53.3	98	98.0
Bolivia	5.80	0.71	44.0	92	92.8
Brazil	4.40	0.76	53.3	100	98.2
Chile	0.30	0.85	44.4	100	99.8
Colombia	4.00	0.80	49.7	99	97.3
Costa Rica	1.10	0.80	48.3	100	99.7
Ecuador	3.20	0.76	44.7	99	94.0
El Salvador	1.90	0.67	38.0	97	97.4
Guatemala	8.80	0.66	48.3	93	94.2
Guyana	11.70	0.68	44.6	91	95.5
Honduras	17.60	0.63	50.5	87	94.8
Mexico	2.20	0.77	46.3	100	99.3
Nicaragua	3.40	0.66	46.2	87	81.5
Panama	2.50	0.81	49.9	100	96.4
Paraguay	1.00	0.73	48.8	99	99.6
Peru	3.40	0.77	43.3	95	91.1
Suriname	23.40	0.73	57.6	97	95.4
Uruguay	0.10	0.81	39.5	100	99.4
Venezuela	10.30	0.74	46.9	99	95.7

To avoid missing data from 2017, data from the last year available is used: *Belize (1998); Guatemala (2014); Guyana (1998); Mexico (2016); Nicaragua (2014); Suriname (1999); Venezuela (2003). **Argentina (2016).

Table 3
Information about the LA countries' NDCs and the projection of the emissions in 2030 according to Climate Energy College (CEC), Climate Action Tracker (CAT), UNEP, and the authors (CAT; Climate and Energy College; UNEP)

	Reference indicator	Reference year	Reduction in 2030* (%)		Emission target in 2030 ($MtCO_{2eq}$) (Unc)			
			Unconditional	Conditional	Authors	CEC	CAT	UNEP
Argentina	Absolute Goal		359 $MtCO_2$		288	442	422	359
Belize	Non quantifiable				1.5	1.5		
Bolivia	Non-quantifiable				55	152		
Brazil	Base year	2005	43.0			1183	890	1394
Chile	Cumulative emissions		1100 $MtCO_{2eq}$		95	149	95	97
Colombia	BAU	2015	51.0		117	131		169
Costa Rica	Absolute Goal		9.11 $MtCO_{2eq}$		12	9	13	9
Ecuador	BAU	2010	9.0	20.9	75	61		
El Salvador	BAU		46.0	61.0	6.7	18		
Guatemala	BAU	2005	11.2	22.6	39	48		48
Guyana	Non-quantifiable				5	5		
Honduras	BAU	2012	-	15.0	27	30		25
Mexico	BAU	2013	22.0	36.0	744	672	763	773
Nicaragua	Non quantifiable				23	19		
Panama	Non-quantifiable				20	21		
Paraguay	BAU	2000	10.0	20.0	129	308		374
Peru	BAU	2010	30.0	40.0	124	84	131	209
Suriname	Non-quantifiable				4	5		
Uruguay	Intensity	1990	43**	47**	48	36		30

Note: Grey emission targets correspond to outdated NDCs and are not considered in this study. *Ecuador, El Salvador, and Uruguay present 2025 targets instead of 2030. **Base year reduction estimation according to Uruguay's NDC.

	Reference indicator	Reference year	Reduction in 2030* (%)		Emission target in 2030 ($MtCO_{2eq}$) (Unc)			
			Unconditional	Conditional	Authors	CEC	CAT	UNEP
Venezuela	BAU	2012	-	20	394	419		340

Note: Grey emission targets correspond to outdated NDCs and are not considered in this study. *Ecuador, El Salvador, and Uruguay present 2025 targets instead of 2030. **Base year reduction estimation according to Uruguay's NDC.

Figures

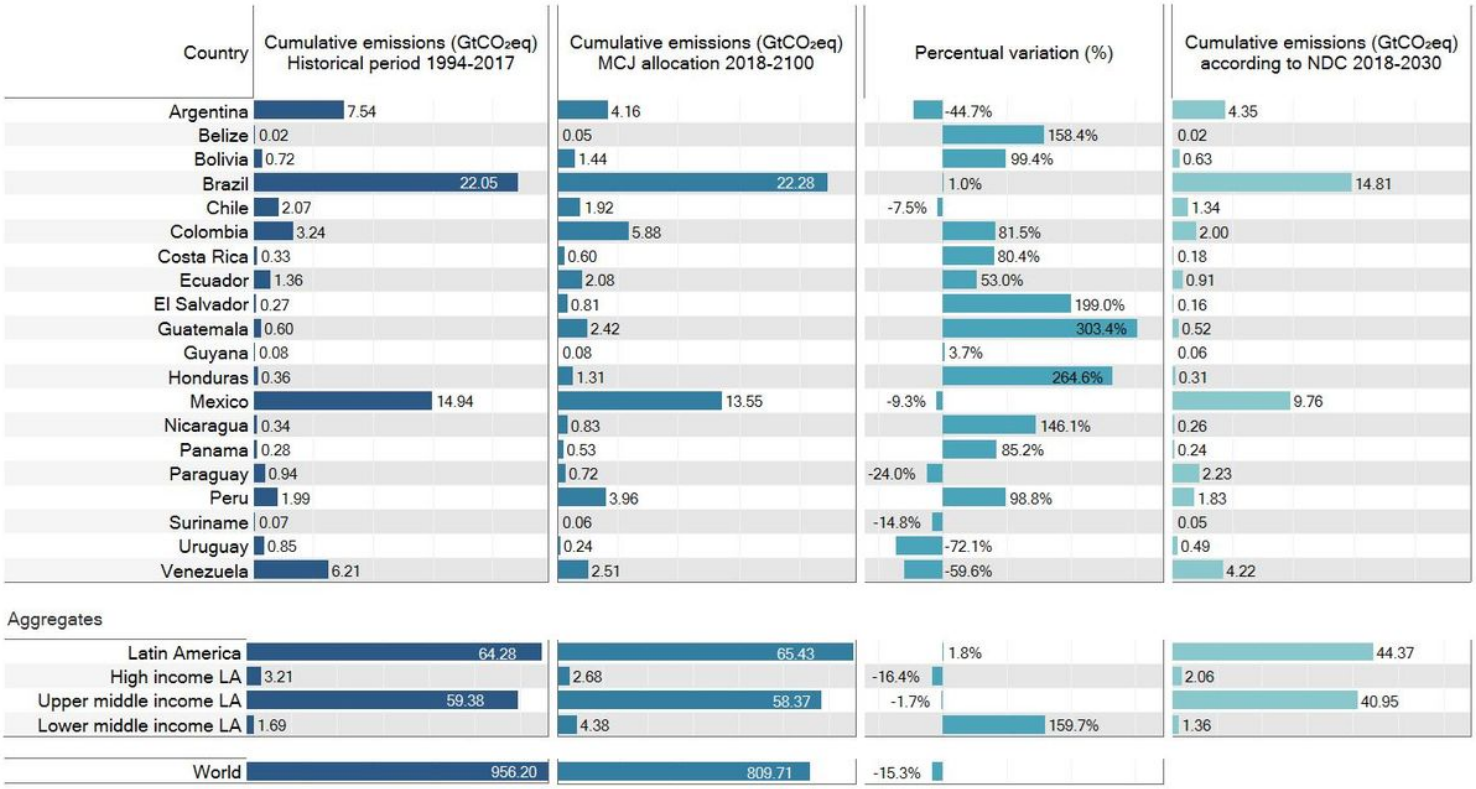

Figure 1

The first column shows the Latin American cumulative emissions for the historical period 1994-2017; the second column shows the cumulative emissions allocated by the MCJ in the future period 2018-2100. The third column is the resulting percentual variation between historical and future allocated emissions. The fourth column indicates the cumulative emissions implied in the countries' NDC for the 2018-2030 period.

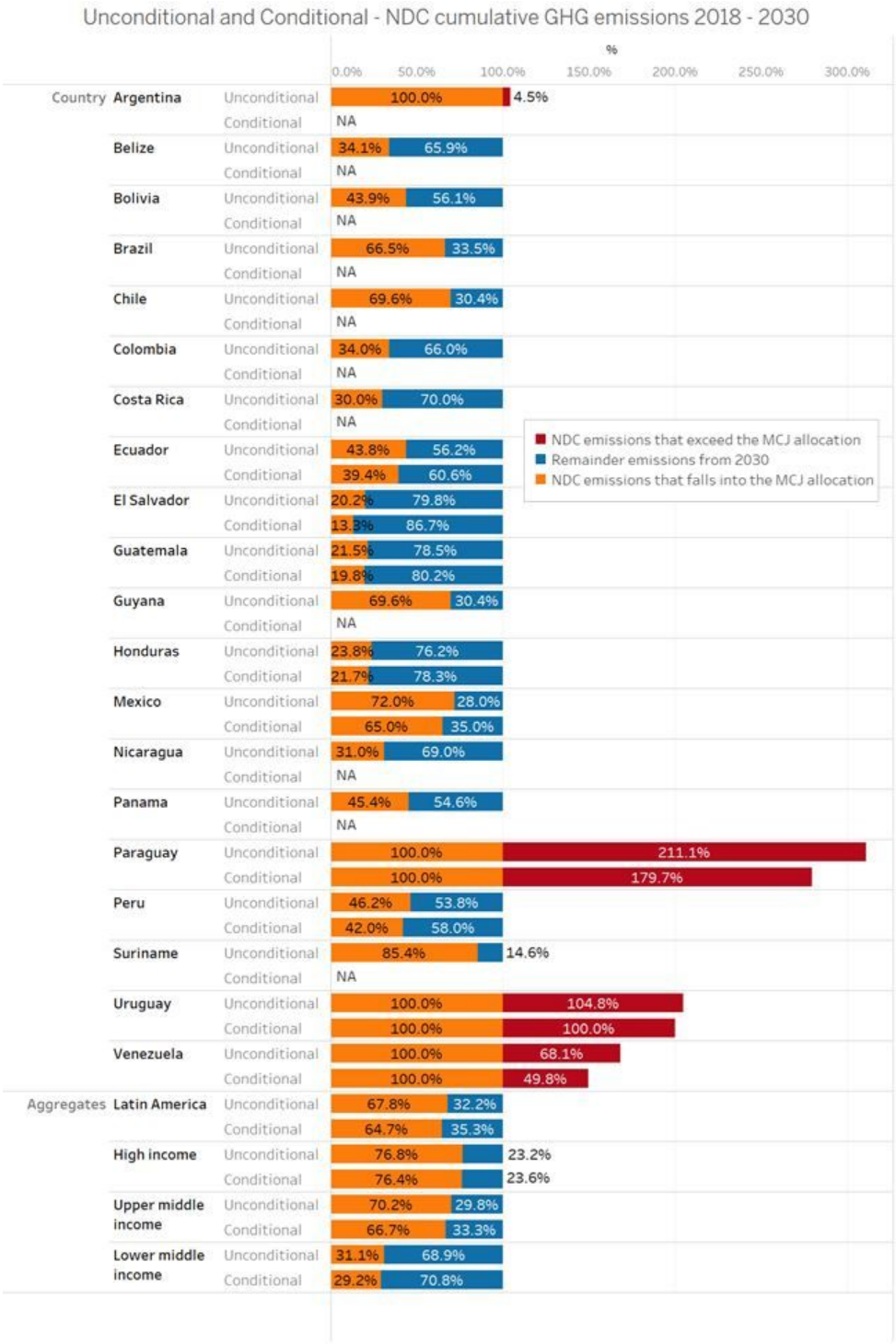

Figure 2

Percentage of cumulative emissions that, according to the current NDCs, will have been released into the atmosphere in 2030 (orange + red bars) with respect to the emissions allocated by the MCJ for the 2018-2100 period. The orange bar indicates the percentage that falls within the allocation, and the red one indicates emissions that exceed the allocation. The blue bar indicates the percentage that would be available for countries from 2030 onwards.

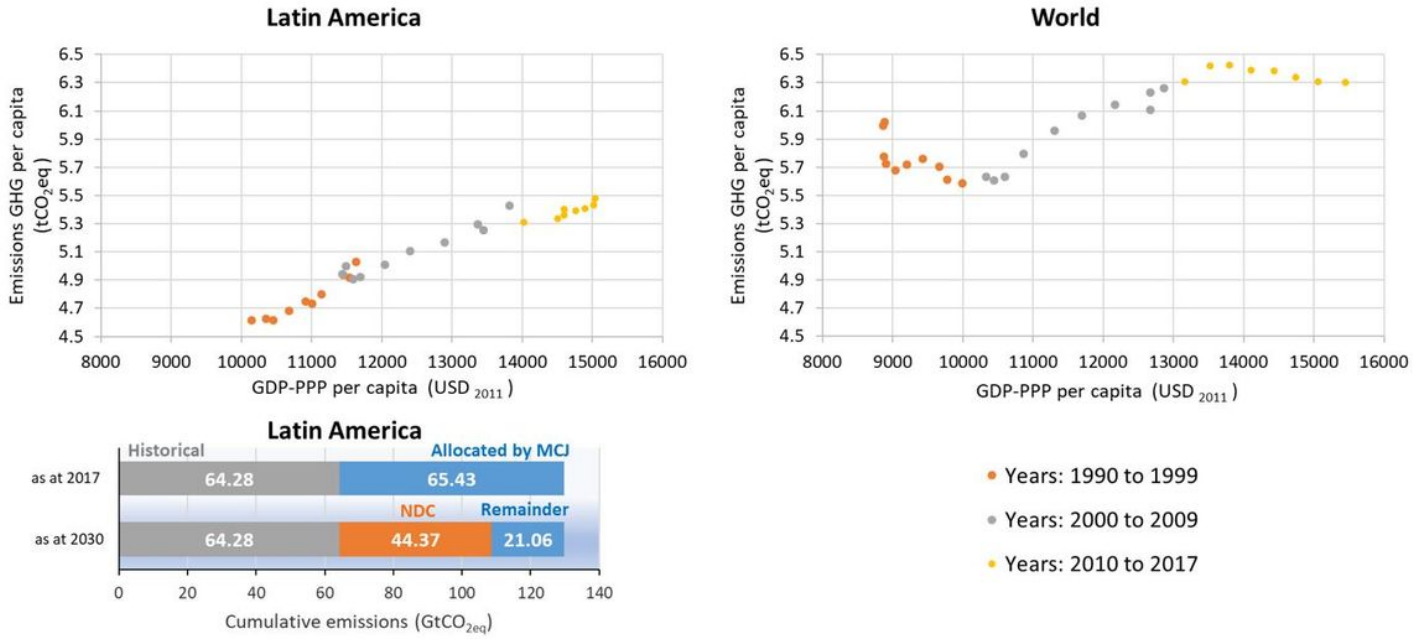

Figure 3

The evolution of emissions and GDP per capita for the LA as an aggregate and the world are compared in the upper section of the figure. The lower left section compares the aggregates for the LA countries' historical and emissions budget until 2030 implied in their NDC as assigned by the MCJ.