



Does climate finance enhance mitigation ambitions of recipient countries?

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ABSTRACT

International public climate finance is an important catalyst for curbing growing emissions from developing countries and enabling them to adapt to the impacts of climate change. Developing countries consider the fulfillment of their Paris Agreement emission reduction pledges to be conditional on receiving climate finance. Prior studies have hypothesized that increasing financial support to developing countries will likely increase their climate ambitions. With the availability of updated Nationally Determined Contributions (NDC) and climate finance data, this article empirically explores this question. Using two empirical strategies, this article found positive but statistically insignificant effect of climate finance on the mitigation ambitions of recipient countries. This effect on mitigation ambition was higher for least developed countries but weaker for small island developing states. This article's analysis should be seen as an initial piece of the puzzle. Findings of this article can inform climate financing strategies of donors enhancing trust with developing countries.

1. Introduction

Limiting temperature increase to a maximum of 1.5–2 °C above the pre-industrial level agreed upon in the Paris Agreement requires a high level of ambition from all nations to progressively deliver emissions reductions (Chan et al., 2022). Based on the common but differentiated responsibility as well as climate justice lens, major responsibility falls on the developed world for their high historical emissions. On the other hand, the development needs of low-income countries will increase their emissions beyond planetary thresholds. Decarbonization and a climate-resilient transition will be challenging for developing countries having a high share of fossil fuels in their energy mix. Furthermore, many developing countries are increasing their emissions significantly in recent years from the conversion of forest lands into agricultural cropping and pastures for cattle raising (Aragon and Njewa, 2022).

However, finance has a pivotal role to play in supporting developing countries to reduce emissions, decarbonize their economies, and adapt to the impacts of climate change (ODI, 2014). Climate finance was intended to be a significant instrument in supporting developing countries to curb their emissions and sustain economic growth (Lee et al., 2022). Previous studies have found that financial support has not only benefited the economies of developing countries by promoting better technologies but also in the reduction of carbon dioxide emissions (Lee

et al., 2022; Li et al., 2022). Climate finance flows to renewable energy had technology spillover effects in promoting cleaner energy generation (Haque and Rashid, 2022) and increased national environmental performance of recipient countries (Lee et al., 2022). It is not surprising to see more than 100 developing countries have put the implementation of their Nationally Determined Contributions (NDC) as conditional on receiving specific levels of climate finance (Pauw and Klein, 2020). On the other hand, financing for adaptation is lagging significantly behind actions for mitigation. Historically, developed countries have been more inclined to funding mitigation than adaptation (Islam, 2022) on the premise of achieving global environmental benefits by stabilizing emissions and therefore rise in temperature, whereas adaptation benefits are viewed to bring in local or national benefit (Khan and Munira, 2021). This has resulted in adaptation finance continuing to be lower than mitigation finance even though the overall flow of climate finance has increased over the years (Pauw et al., 2020; Yeo, 2019).

The 2021 Adaptation Gap Report highlighted the importance of international public support to further increase adaptation ambition since the private sector, particularly in developing countries, is shy of putting money in high-risk, low-return opportunities. Building on this notion, Khan and Munira (2021) suggested that adequate support for climate adaptation may encourage developing countries to go for higher mitigation. Pauw and Klein (2020) also theorized that a lack of support could

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have a negative effect on the ambition of future NDCs. In other words, if the effective implementation of a developing country's NDC depends partly on international support, this country is more likely to increase its ambition if it can expect support to be forthcoming (Pauw and Klein, 2020). Testing this hypothesis was not possible until now as higher mitigation ambition could not be uniformly assessed for all climate aid recipient countries. Article 4 of the Paris Agreement established periodic reviews and updates of NDCs so that these can become more ambitious over time (Pauw et al., 2020; Zaman, 2023). With the updated NDCs submitted by countries before the 26th Conference of Parties (COP26) in 2021 and the availability of climate finance data from OECD from 2015 to 2020, the time is ripe to empirically assess the nature of this connection between climate finance support and ambition in mitigation. The main aim of this study is to address the research question - did prior climate finance commitments made to countries lead to an increase in their mitigation ambitions? In the process, we modified the original hypothesis proposed by Khan and Munira (2021) to include total climate finance received by countries instead of just adaptation finance as existing literature highlights the disproportionate lower commitment for the latter (Pauw et al., 2020; Xie et al., 2023; Yeo, 2019).

The article is organized as follows: in section 2, a literature review is presented summarizing prior empirical studies on the impacts of climate finance while also noting the novelty of this article. Section 3 explains the data and methodology applied to answer the research question, and the results are presented in Section 4. Discussion and conclusion are presented in sections 5 and 6 respectively.

2. Literature review

Previous empirical studies on climate finance were instrumental in the design of this study. However, this paper is unique in understanding the effects of climate finance on mitigation ambitions as highlighted by the changes made in the NDCs, which have not been studied before. In this article, the difference in ambition is understood as the differences between NDCs of developing countries submitted in 2015 and 2020, and it explores how climate finance affected this change. The Paris Agreement requires all countries to put forward their pledges through NDCs and to strengthen their efforts every five years (Jin and Kim, 2017; Zaman, 2023). This includes requirements that all countries regularly report on their emissions and implementation efforts (Jernnäs, 2023). The pledge and review process every five years will measure the progress made on their NDCs through a technical expert review (Iyer et al., 2017). NDCs are national in scope and should theoretically address all major sources of national greenhouse gas emissions, or at least the most significant ones. Many countries proposed economy-wide mitigation targets, with absolute emission-reduction targets below the level in a specified base year (Mayer, 2023). Other NDCs contain absolute targets that are not linked to a base year but establish an overall maximum absolute limit on emissions (Jin and Kim, 2017). While diverse in their methodology, composition, metrics, and length (Mohan, 2023), NDCs represent countries' commitments to achieving the Paris Agreement goals (Chebly, 2021). Jernnäs (2023) highlights some interesting paradoxical narratives and practices in such a bottom-up pledge-based arrangement under the Paris regime. First, the national determination of NDCs is countered with a mechanism for international review. Second, diverse initiatives are accompanied by an apparent need to quantify, calculate, and aggregate all greenhouse gas emissions. Lastly, this worldwide momentum of pledge-based climate action is still not enough when confronted with reports on the alarming 'emissions gap' for reaching the 2 °C temperature goal (Jernnäs, 2023). Nonetheless, scaling up climate finance is a significant prerequisite for progress in mitigation outlined by developing countries in their NDCs (Jin and Kim, 2017; Khan et al., 2020).

Lee et al. (2022) found that climate finance significantly reduces carbon dioxide emissions of recipient countries and mitigation finance has a greater effect on emissions reduction compared to the effects of

adaptation finance. Whereas Lee et al. (2022) found that climate finance received by Small Island Developing States (SIDS) had significant effects on the reduction of carbon dioxide emissions, the reduction effect was not found significant by Li et al. (2022). Mitigation finance is flowing more toward countries with middle and higher-income and fast-growing emissions, whereas low-income countries benefit less in comparison (Lee et al., 2022; Pauw et al., 2020; Xie et al., 2023). According to Islam (2022), understanding the effects of GDP per capita as a proxy of income on mitigation funding can be mixed and complex, depending on donor rationality. Rational, efficiency-driven donors are inclined to direct mitigation funding to countries with higher GDPs providing opportunities for more significant emission reduction (Li et al., 2022; Xie et al., 2023). Such opportunities are limited in low-income countries. Islam (2022) provides a review of studies finding both positive and negative effects of GDP per capita on funding flows. Recipient country's population size is another variable included in several studies with the reasoning that larger countries will need more climate finance support (Islam, 2022). Heterogeneity analysis of Wu et al. (2021) shows that climate aid has a significant carbon reduction effect in middle-income recipients only, whereas the effect is insignificant for low-income and high-income recipient countries. Similar results were observed for emission levels of countries, where carbon reduction effects were found to be more significant in middle emission level countries (Wu et al., 2021).

A recipient country's identification as one of the SIDS and Least Developed Country (LDC) is another variable used in multiple studies as both groups have been accorded priority in the Climate Convention and the Paris Agreement for climate finance and capacity building support (Pauw et al., 2020). Due to their remoteness, isolation, and vulnerability to climate disasters, SIDS are highly dependent on foreign aid and international cooperation (Zhang and Managi, 2020). Climate finance provides an opportunity for the international community to help SIDS address these challenges. Lee et al. (2022) found that the average ratio of climate finance to GDP in SIDS is higher compared to non-SIDS. However, some Caribbean SIDS have difficulties accessing international climate finance as their upper-middle and high-income status makes them ineligible for traditional development assistance (Mohan, 2022). There is also evidence that suggests that predetermined country groupings such as LDC and SIDS are less helpful in securing more adaptation funding when compared to vulnerability defined in relation to current and anticipated climate change impacts (Ciplet et al., 2022). Literature on climate finance flows to vulnerable countries is also inconclusive as some researchers found that donors tend to prioritize the most vulnerable countries (Scandurra et al., 2020), while other researchers found no correlation using different indicators and datasets as proxies for finance flows and vulnerability (Qian et al., 2023; Weikmans, 2023).

These findings highlight the need to control for variables such as income level, share of global emissions, emissions per capita, and population size – as these are influential elements for deciding the mitigation ambitions of recipient countries, but also prioritization for climate finance from donor communities (Haque and Rashid, 2019; Klöck et al., 2018; Weiler and Sanubi, 2019). However, our analysis is a departure from earlier studies exploring determinants of higher climate finance flows and the impact of climate finance on environmental performance. It is one of the few studies that explore the impact of climate finance on the process of NDC development. As 'country-driven' climate action plans, NDCs are expected to align donor and recipient expectations for climate finance by making recipient country needs more explicit (Pauw and Klein, 2020). However, Iacobuță et al. (2022) did not find such alignment between NDC activities and climate-relevant finance when comparing pre-and post-Paris periods. Low-income countries put forward a larger number of activities in their NDCs compared to middle-income groups, despite having received less climate-relevant finance per capita. Enhancing climate finance flows to these countries, which have higher conditional greenhouse gas emissions per capita

reduction targets, could ensure a higher chance of success for the Paris Agreement (Iacobuță et al., 2022; Wu et al., 2021).

3. Data and methodology

It is our main interest to study whether climate finance commitments after the Paris Agreement led to an increase in recipient countries' ambitions in their revised NDCs.

3.1. Dependent variable

Our analysis focuses on NDC pledges submitted by 138 countries in 2015 and 2020. Empirical research using emission targets in NDCs as an indicator of climate ambition is scarce. The heterogenic nature of the international agreement outcomes and the high likelihood of discrepancies between a country's reported ambition and actual action can be considered reasons for this scarcity (Lamb and Minx, 2020). With the recent availability of at least two versions of NDCs per country, an empirical investigation of mitigation ambition using NDC pledges is worth exploring. However, the issue of heterogeneity and discrepancy associated with NDC still remains especially since targets are sometimes expressed as economy-wide efficiency, in absolute terms, or sectoral targets against business-as-usual scenarios (Mayer, 2023; Nikolova and Ryder, 2021; Pauw and Klein, 2020). To minimize the inherent complexity of using NDCs as a dependent variable, two empirical methodologies have been applied in this study to test the hypothesis of whether mitigation ambition is being driven by aggregate climate finance support between 2015 and 2020.

This study uses NDC pledge data sourced from NDC enhancement tracker tool of Climate Watch,¹ developed by the World Resources Institute (WRI). The raw dataset of this tool includes harmonized emission reduction targets in 2015 and 2020 for every country. The first dependent variable of this study, *NDC*, is created by taking the difference between a country's emission targets pledged in the year 2015 NDC and the 2020 updated NDC. A negative difference in emission targets reflects an increase in its mitigation ambition considering domestic realities, whereas a positive difference is still considered as mitigation ambition but a weaker one. However, due to the nature of NDC pledges, emission reduction targets differ widely in magnitude among countries (see the first row of Table 1). To reduce the possibility of misleading results, standardized values of emission targets and climate finance commitment data, using typical z-score formula, have been used in the regression analysis (Anderberg, 2014; Romesburg, 2004). The Climate Watch databank also provides qualitative information of a country's NDC status for the year 2020. It includes whether countries have submitted an updated NDC with reduced total emissions or not (Climate Watch, 2020). Our second dependent variable is created utilizing this qualitative information of 2020 NDC status as a dummy variable. The variable takes the value '1' if the country has "submitted an updated NDC with reduced total emissions" whereas a '0' value is assigned if the country only "submitted an updated NDC (no changes in total emissions)." The final list of countries includes China but excludes India as the latter only submitted its updated NDC in 2022 after COP26.

3.2. Independent variable

To avoid the definition muddle of climate finance, this paper considers only international public climate finance flows to eligible recipients under OECD Development Assistance Committee (DAC) (Anantharajah and Setyowati, 2022; Shishlov and Censkowsky, 2022). Our main independent variable, the total amount of climate finance commitment from 2015 to 2020, is collected from Aid Atlas² online tool

developed by Stockholm Environment Institute (SEI). Aid Atlas contains data on international public climate finance flows that are sourced from OECD DAC but disaggregated by countries and sectors (Atteridge et al., 2019). An advantage of using Aid Atlas is the availability of finance for climate change (total), enabling researchers to combine the data for *Rio Markers of climate change mitigation* and *climate change adaptation* without double counting projects that may overlap the two categories. This study focuses on commitment level rather than disbursement as the dependent variable of ambition is also a commitment in theory. Aid Atlas's climate data is based on OECD's climate-related development finance data which only includes commitments made by bilateral and multilateral donors, thereby limiting the scope of this study focusing only on commitments. Although NDC data are available for 194 countries, our empirical analysis considers only countries that received climate finance between 2015 and 2020. Country-specific commitment total is created by adding annual committed climate aid over the period of 2015–2020 followed by log transformation. Aggregate commitment data has been standardized before running econometric techniques.

3.3. Control variables

Section 2 highlighted the importance of several country factors that influence climate mitigation ambitions. In our model specification, we added a set of control variables that might influence mitigation ambition which are institutional, economic, and geographical factors related to climate. The degree of vulnerability of a country to climate change can explain its response toward mitigation ambition (Tørstad et al., 2020; Xie et al., 2023). Like other studies (Islam, 2022; Jain and Bardhan, 2022; Weiler and Sanubi, 2019; Xie et al., 2023), this paper also uses the exposure variable provided by the Notre Dame Global Adaptation Index (ND-GAIN) to capture climate vulnerability. Relevant economic factors used in our empirical analysis include GDP per capita, export as a percentage of GDP, the share of global emissions, emissions per unit of GDP (CO₂/GDP), emissions per capita (CO₂/capita), and the logarithm of total greenhouse gas emission (kg) – sourced from the World Development Indicators database of the World Bank. From this database, we also included PM2.5 air pollution (% of the total population exposed) assuming it to be an important driver for a developing country to enhance mitigation ambitions. The data for the share of renewables in total electricity generation capacity is sourced from International Renewable Energy Agency (IRENA). The final sample comprises 138 countries from 2015 to 2020. Since the dependent variable capture the difference in target emission reported in 2015 and 2020, for each control variable (except categorical and dummy variable), we have calculated the average value within the sample period of 2015–2020. Table 1 provides summary statistics for all variables (except the categorical income level variable), and Table 2 presents the correlation matrix confirming the absence of strong correlation among variables.

3.4. Model specification

For our analysis, we have applied two statistical techniques. Ordinary least square (OLS) is applied to the standardized NDC pledge data and logistic regression is applied for the alternative method for computing mitigation ambition as a robustness check. We have estimated the following general model:

$$y_i = \alpha + \beta_1 \text{Commit}_i + \beta_2 VI_i + \beta_3 glob_i + \beta_4 D_R + \beta_5 X_i + e_i \quad (1)$$

Where y_i captures two different measures of NDC ambition of the country i . Commit_i represents the aggregate value of climate finance commitments made to the i th country. VI_i and $glob_i$ are the i th country's vulnerability index and percentage share of total global emissions respectively. Vector X_i contains economic and geographical controls influencing a country's NDC pledges. D_R contains regional dummies for SIDS and LDCs (Weiler and Klöck, 2021). We also interact total climate

¹ <https://www.climatewatchdata.org/2020-ndc-tracker>.

² <https://aid-atlas.org/>.

Table 1
Summary statistics for all numerical variables used in the statistical models.

	Years	Mean	St. Deviation	minimum	maximum	Valid N
NDC	(emission target set in 2020 minus the emission target set in 2015)	34.0416	182.7029	-642	1830.02	138
Commitment (log)	Sum of 2015–2020	18.186	1.69694	9.1911	20.836	135
CO ₂ /GDP (in kg)	Avg. of 2015–2020	0.4927	0.35465	0.0727	1.9374	134
Export/GDP	Avg. of 2015–2020	31.459	18.473	0	139.73	123
GDP/capita (in USD, 2015)	Avg. of 2015–2020	4489.6	4063.1	286.14	16650.93	136
PM _{2.5} (% of total population)	Avg. of 2015–2020	97.671	11.524	2.29e-08	100	134
REelegen (in %)	Avg. of 2015–2020	37.205	33.721	0	100	136
Vulindex (ND-GAIN)	Avg. of 2015–2020	0.4755	0.0801	0.3267	0.6776	129
Globalshare (in %)	Avg. of 2015–2020	0.4575	2.179	0	24.23	137
Poptotal (log)	Avg. of 2015–2020	15.659	2.258	9.2702	21.058	137

Table 2
Correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Commitment	1.000									
(2) CO ₂ /GDP (kg)	-0.093	1.000								
(3) CO ₂ /capita (mt)	-0.301	0.609	1.000							
(4) EX/GDP	-0.306	0.102	0.274	1.000						
(5) GDP/Cap	-0.359	0.039	0.630	0.328	1.000					
(6) PM2.5	-0.015	0.103	-0.087	-0.112	-0.372	1.000				
(7) REelegen	0.184	-0.349	-0.367	-0.167	-0.107	-0.042	1.000			
(8) Vulindex	0.135	-0.473	-0.296	-0.605	0.080	-0.290	0.049	1.000		
(9) globeshare	0.168	0.133	-0.108	0.139	0.009	0.449	-0.072	-0.120	1.000	
(10) poptotal	0.372	0.140	-0.446	-0.173	0.087	0.046	0.047	-0.045	0.040	1.000

finance commitment with SIDS and LDC dummy to determine the implication of the joint association of extreme vulnerability conditions and climate finance on NDC pledges (Commitment*SIDS, Commitment*LDC).

Table 3
Impact of aggregate climate finance commitment on NDC pledges: OLS Model.

	Dependent variable: NDC ambitions		
	Model-1	Model-2	Model-3
Commitment	0.0524 (0.0405)	0.0516 (0.0457)	0.0591 (0.0508)
LDC		0.132 (0.219)	
SIDS			-0.1611 (0.195)
LDC*Commitment		0.0362 (0.1526)	
SIDS*Commitment			-0.0378 (0.0551)
Global share (%)	0.3725*** (0.0504)	0.373*** (0.0500)	0.375*** (0.0497)
Vulnerability index	-0.634 (1.157)	-0.9171 (1.316)	-0.7067 (1.221)
RE electricity generation (%)	-0.0012 (0.0021)	-0.0011 (0.002)	-0.0015 (0.1819)
GDP/Capita (log)	0.0171 (0.081)	0.0543 (0.0961)	0.0139 (0.0808)
CO ₂ (kg)/GDP	-0.124 (0.163)	-0.103 (0.169)	-0.157 (0.182)
Export (% GDP)	-0.0037 (0.004)	-0.0043 (0.0037)	-0.0045 (0.0043)
Population total (log)	-0.0619 (0.0583)	-0.0653 (0.0606)	-0.081 (0.077)
PM _{2.5}	0.0045 (0.0033)	0.0044 (0.0034)	0.004 (0.0035)
Constant	0.2179 (1.899)	0.081 (1.889)	0.640 (2.405)
No of countries	114	114	114
R ²	0.6260	0.6274	0.627
F statistic	7.35***	6.55***	6.16***

Notes: Robust standard errors are given in parentheses. ***p < 0.01, **p < 0.05, *p < 0.10.

4. Results

Table 3 presents baseline empirical findings applying OLS techniques based on our estimation of equation (1). Model 1 presents results without interaction terms, whereas Model 2 and Model 3 present the findings with interaction terms. The positive coefficients of aggregate commitment level indicate a direct association between NDCs and climate aid; however, this effect is found to be statistically insignificant. The positive and highly significant global share of emissions reveals that being a major global emitter is the crucial driving force for increasing mitigation ambition. The positive coefficient of the interaction term between LDC and aggregate commitment of climate funds indicates that an increase in climate finance targeted to LDCs is associated with higher NDC ambitions. Therefore, the inflow of climate money appears to motivate climate vulnerable LDCs to pledge higher NDC ambitions. However, the coefficient of aggregate commitment for SIDS is positive, and the interaction term is negative. Although increased climate finance can positively influence NDC ambition, for highly vulnerable SIDS the impact is slightly weaker. Unfortunately for both LDCs and SIDS, these coefficients are statistically insignificant.

4.1. Robustness check

As a robustness check, NDC ambitions of countries are captured using a different approach. The logistic regression model is applied to the indicator variable measuring NDC ambition. We found that aggregate climate finance is positively associated with enhanced NDC ambitions. Logistic regression results are presented in Table 4. However, the results are still statistically insignificant. We again find a positive influence of commitment on increasing NDC ambition for most vulnerable LDC and SIDS, as the coefficients of the interaction terms are positive (see Model 2 and Model 3). The share of global emissions is significantly associated with increased NDC pledges. However, vulnerability was also found to be significantly affecting ambition and the effect is relatively large (see Model 1). This implies the probability of enhancing mitigation ambition is significantly lower for extremely climate-vulnerable countries.

Table 4
Impact of aggregate climate finance commitment on NDC pledges: Logistic Model.

	Dependent variable: NDC ambitions (Dummy)		
	Model-1	Model-2	Model-3
Commitment	0.1634 (0.153)	0.1168 (0.159)	0.129 (0.160)
LDC		0.340 (0.432)	
SIDS			0.3537 (0.5514)
LDC*Commitment		0.521 (0.522)	
SIDS*Commitment			0.773 (0.7146)
Global share (%)	0.0188* (0.654)	0.0347* (0.07)	0.0149 (0.066)
Vulnerability index	-9.312*** (2.923)	-11.897*** (3.467)	-9.42*** (2.998)
RE electricity generation (%)	-0.003 (0.0042)	-0.0047 (0.0043)	-0.0026 (0.0046)
GDP/Capita (log)	-0.0001 (0.0006)	-0.0001 (0.0005)	-0.00009 (0.0006)
CO ₂ (kg)/GDP	-0.598 (0.472)	-0.654 (0.477)	-0.565 (0.498)
Export (% GDP)	-0.009 (0.008)	-0.0111 (0.009)	-0.0078 (0.0091)
Population total (log)	-0.0157 (0.0834)	-0.0494 (0.0884)	0.0105 (0.107)
PM _{2.5}	0.0174 (0.0834)	0.0154 (0.0218)	0.0181 (0.0219)
Constant	3.937 (3.472)	5.865 (3.669)	3.375 (3.816)
No of countries	114	114	114
Pseudo R ²	0.226	0.274	0.261

Notes: Robust standard errors are given in parentheses. ***p < 0.01, **p < 0.05, *p < 0.10.

4.3. Limitations of empirical strategy

There has been some criticism of using aggregate climate finance data over four to six-year periods as this aggregation may portray a static model of funding, whereas funding decisions by donors are more dynamic (Islam, 2022). However, our model answers a different question where the dependent variable of raising ambition is the responsibility of the recipient country's government. Therefore, this limitation of model framing is tolerated. Limitations of OECD's climate-related development finance dataset (used by Aid Atlas) are also applicable to this study. This includes relying on commitment figures instead of disbursement as the OECD dataset does not include disbursements. Another criticism of the data is that climate aid measured with Rio markers lacks both validity and reliability, as donors overreport their efforts to varying degrees, and there is no system in place for verifying donor claims (Kono and Montinola, 2019; Qian et al., 2023; Rumney et al., 2023). As for the two dependent variables, the varying methodologies for measuring emission reductions as well as the simple textual comparison of new NDCs adopted by ClimateWatch's NDC Enhancement Tracker may not fully capture the changes in sectors, conditions, and coverage of mitigation objectives, which are necessary to establish progression (Mayer, 2023). Additional variables can be included in future studies that consider recipient countries' rate of deforestation, amount of carbon sinks, and potential of carbon markets as predictors of higher mitigation ambition (Piris-Cabezas et al., 2023) and determinants for receiving more climate finance. These variables were not added in the current study due to data unavailability for all sample countries. Additional studies are warranted to check ambition differences for adaptation expressed in terms of an increase in the number of sectors, population groups, geographic coverage, or additional policies considered for adaptation (Pauw and Klein, 2020). Future studies can also apply different datasets and statistical techniques to address other uncertainties.

5. Discussion

This article sets out to answer the title question of whether climate finance enhances the mitigation ambition of recipient countries. Our

empirical results have found that climate finance flows to developing countries positively affect their mitigation ambitions, although the effect is found to be statistically insignificant. This finding is consistent with recent trends where NDC updates aren't significantly tied to financial support requirements. The updated NDCs submitted in recent years are found to be moving away from being entirely conditional to NDCs making commitments that are partly unconditional (Fransen et al., 2022). According to Mayer (2023), this move to unconditional NDC objectives can itself be labeled as a progression or enhancement of mitigation ambition. However, Fransen et al. (2022) observed that there is no clear relationship between changes in conditionality and changes in mitigation ambition. These interpretations require some caution as the inclusion of finance requirements in NDCs is voluntary, and there is a lack of standardized definition and methodology that can allow a comparison of NDCs on finance requirements (Fransen et al., 2022). Although this analysis does not include conditional NDC as a variable, our results are relatable in the sense that external financial support is no longer considered a game-changer for ratcheting up the mitigation ambitions of developing countries. In local contexts of Fiji and Indonesia, climate finance was found to have a limited effect on co-benefits and employment generation thereby challenging aspirational views of climate finance (Anantharajah and Setyowati, 2022). Researchers from Indonesia are already lamenting the lack of international support for emissions reduction due to the non-alignment of donor preferences with recipient country sector needs (Suroso et al., 2022). Similarly, Mohan (2022) notes that although Caribbean SIDS experience climate-related disasters that can erase decades of development in a single event of natural disaster, these countries do not benefit from international aid or debt relief. These experiences and sentiments reflect a divergence of trust between developed and developing countries on international climate finance.

There could be other endogenous reasons for developing countries not significantly responding to climate finance commitments with enhanced NDC ambition as found in our analysis. Apart from external climate finance, Fransen et al. (2022) note that countries may enhance their ambition because of exogenous factors such as falling technology costs, or endogenous ones such as improved stakeholder consultations supporting more robust mitigation interventions. Some caution is warranted to understand updated NDC submissions in the global context. Most of the updated NDCs were developed and submitted during the COVID-19 pandemic, which could explain why greenhouse gas emissions reduction commitments were low and insufficient from climate finance recipient countries (Nikolova and Ryder, 2021). Since many developing countries already submitted ambitious NDCs in 2015, their ability to put forward more ambitious proposals in 2020 was also limited (Jin and Kim, 2017). Many developing countries could also be reluctant to seek climate finance due to its availability in the form of loans for Official Development Assistance (ODA) repackaged by donors as climate finance (Munira et al., 2021). Navigating the largely fragmented international climate finance sources requires complex efforts which may also aggravate the recipient country's economic risks (Zhao et al., 2022).

The findings of this article also highlight the unclear relationships between climate ambition and national income, as well as population and current emissions (Nikolova and Ryder, 2021). However, our analysis found that a developing country's global share of greenhouse gas emissions was found to have a positive and statistically significant influence on NDC ambition. The importance of global share of emissions on mitigation ambitions is already playing out in climate diplomacy where greater support is offered for high-emitting countries. In the G20 summit of 2022, Indonesia pledged to sharply reduce its reliance on fossil fuel and speed up its transition to renewable power as part of a \$20 billion climate finance deal with the United States, Japan and other developed countries. A similar Just Energy Transition Partnerships (JET-P) arrangement has been agreed upon with South Africa in 2021, and discussions are being held with Vietnam, Senegal, and India for separate deals (Plumer, 2022). If Indonesia sticks to its JET-P promises

by shutting multiple coal plants, it will limit annual power emissions to 290 megatons in 2030 and become one of the few countries with emissions close to those required for a world with only 1.5 °C of warming (The Economist, 2023). Such preference for higher-income countries increases climate finance inequalities and challenges the opportunities for climate finance allocation to be need-based (Jain and Bardhan, 2022). Climate finance providers should focus their efforts on a variety of recipient countries rather than assisting those that are already being helped with climate change (Causevic et al., 2023; Weiler and Klöck, 2021).

An interesting finding of this article is the negative relationship found between vulnerability and mitigation ambitions of recipient countries, which was found to be statistically significant in the logistic model (Table 4). It highlights that developing countries are not enhancing their NDC ambitions only because of their vulnerability to climate impacts. This finding also alludes to the trust deficit in climate-vulnerable countries in receiving timely climate finance which is weakening their resolve to enhance their emission reduction ambitions. The difference in ambition found between LDCs and SIDS in relation to climate finance commitments also warrants further investigation. The policy implication of these findings is for climate finance providers to redefine the criteria for climate commitments. To increase the effective use of limited concessional funds in countries with high vulnerability, the donor community must provide greater technical assistance for capacity building to these nations (Jain and Bardhan, 2022). Since the transition from fossil fuels is likely to take a long time to overcome lock-in effects, more climate finance support for decarbonizing key sectors in developing countries including in the LDCs and SIDS will serve as win-win options both for mitigation and adaptation. This should arise from a moral as well as a legal obligation to assist vulnerable developing countries deal with the adverse effects of climate change (Weikmans, 2023). It takes money both to reduce greenhouse gas emissions and to adapt to their consequences. Low-income climate-vulnerable countries are not able to do much of either.

6. Conclusions

The transition of developing countries to low-carbon, climate-resilient economies will not happen overnight and will require significant financial support and investments. Transparency in allocating international public climate finance will build trust and confidence for the effective implementation of the Paris Agreement. A major reason for the trust deficit is the questionable accounting methodology used under the Rio Marker by climate finance providers (Rumney et al., 2023). Reaching a consensus on what really counts as climate finance may foster a more positive response from developing countries which can also include a higher mitigation ambition. Additionally, narrowing down the continued large discrepancy between commitments and disbursement of climate finance may encourage recipient countries to undertake higher mitigation ambition.

The updated NDCs demonstrate that the Paris Agreement's "ratchet mechanism" can deliver improved mitigation outcomes, although there are questions on how it can be done at the scale and pace needed (Fransen et al., 2022). More research is needed to identify the factors influencing developing countries to set higher emission reduction targets in their NDCs. This study found that climate finance is yet to be the determining factor for ratcheting up the mitigation ambitions of developing countries, as previously assumed. However, there is room for improvement to change this *status quo* for the next round of NDC submissions. The first Global Stocktake (GST) of the Paris Agreement will conclude in 2023 representing opportunities to reflect on international climate cooperation and feed into a new round of NDCs (van Asselt et al., 2023). The outcome of the global stocktake has the potential to create a political moment to catalyze greater ambition in mitigation (Zaman, 2023). While global ambition related to emissions and international climate finance will likely be assessed separately, there is a need to

reflect on their connections. It is of academic and policy relevance to understand if financial intermediation can affect emission trajectories in developing countries. This study offers an example of establishing this connection which can be carried out differently in the future as new rounds of NDCs and more annual climate finance data becomes available.

In the meantime, climate finance planning by donors could consider developing countries' needs based on their NDCs for funding to be better targeted. NDC-aligned finance can ensure support for the implementation of country commitments to the Paris Agreement (Chebly, 2021). On the other hand, developing countries also need to provide more information about specific actions to be financed as current NDCs are often too general (Mohan, 2023; Scandurra et al., 2020; van Asselt et al., 2023). Adding tracking standards for NDC progress may also motivate donors to consider NDCs specifically when allocating funds (Chebly, 2021). As the next round of NDCs is due by 2025, countries need to turn their attention to strengthening their commitments even as they implement the commitments they have already made. At the same time, making the climate commitment process transparent from climate finance providers will go a long way in addressing equity and enhancing the ambitions of developing countries. Climate finance providers must rebuild trust with developing countries to achieve the objectives of the Paris Agreement by delivering timely climate finance for implementing successive NDCs.

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Data availability

Data will be made available on request.

References

- Anantharajah, K., Setyowati, A.B., 2022. Beyond promises: realities of climate finance justice and energy transitions in Asia and the Pacific. *Energy Res. Social Sci.* 89, 102550 <https://doi.org/10.1016/j.erss.2022.102550>.
- Anderberg, M.R., 2014. In: *Cluster Analysis for Applications: Probability and Mathematical Statistics: a Series of Monographs and Textbooks*, vol. 19. Elsevier. <https://doi.org/10.1016/C2013-0-06161-0>.
- Aragon, I., Njewa, E., 2022. Urgent but overlooked: a spotlight on the long-term finance goal of the Paris Agreement. *International Institute for Environment and Development*. <http://pubs.iied.org/21056iied>.
- Atteridge, A., Savvidou, G., Sadowski, S., Gortana, F., Meintrup, L., Dzebo, A., 2019. *Aid Atlas*. <https://aid-atlas.org>.

- Causevic, A., Haque, N., LoCastro, M., Selvakkumaran, S., Beslik, S., Causevic, S., 2023. Assessment of the post-paris agreement era: international public climate finance in countries with low governance scores. *SAIS Review of International Affairs* 43 (1), 75–99. <https://doi.org/10.1353/sais.2023.0002>.
- Chan, S., Hale, T., Deneault, A., Shrivastava, M., Mbeva, K., Chengo, V., Atela, J., 2022. Assessing the effectiveness of orchestrated climate action from five years of summits. *Nat. Clim. Change* 12 (7), 628–633. <https://doi.org/10.1038/s41558-022-01405-6>.
- Chebly, J.E., 2021. Aligning climate finance to NDCs and long-term strategies. In: Dash, Jan W. (Ed.), *World Scientific Encyclopedia of Climate Change*. World Scientific Publishing Co. Pte. Ltd. https://doi.org/10.1142/9789811213946_0005.
- Ciplet, D., Falzon, D., Uri, I., Robinson, S., Weikmans, R., Roberts, J.T., 2022. The unequal geographies of climate finance: climate injustice and dependency in the world system. *Polit. Geogr.* 99, 102769. <https://doi.org/10.1016/j.polgeo.2022.102769>.
- Climate Watch, 2020. World Resources Institute, Washington, DC. <https://www.climatewatchdata.org>.
- Fransen, T., Henderson, C., O'Connor, R., Alayza, N., Caldwell, M., Chakrabarty, S., Dixit, A., Finch, M., Kustar, A., Langer, P., Stolle, F., Walls, G., Welle, B., 2022. The State of Nationally Determined Contributions: 2022. World Resources Institute. <https://doi.org/10.46830/wri rpt.22.00043>.
- Haque, N., Rashid, S., 2019. Host country characteristics attracting climate projects through public-private partnerships. *Green Finance* 1 (4), 405–428. <https://doi.org/10.3934/GF.2019.4.405>.
- Haque, N., Rashid, S., 2022. Effects of cumulative energy aid projects on renewable energy generation capacity. *Environmental Development* 42, 100692. <https://doi.org/10.1016/j.envdev.2021.100692>.
- Iacobuță, G.I., Brandi, C., Dzebo, A., Elizalde Duron, S.D., 2022. Aligning climate and sustainable development finance through an SDG lens. The role of development assistance in implementing the Paris Agreement. *Global Environ. Change* 74, 102509. <https://doi.org/10.1016/j.gloenvcha.2022.102509>.
- Islam, Md M., 2022. Distributive justice in global climate finance – recipients' climate vulnerability and the allocation of climate funds. *Global Environ. Change* 73, 102475. <https://doi.org/10.1016/j.gloenvcha.2022.102475>.
- Iyer, G., Ledna, C., Clarke, L., Edmonds, J., McJeon, H., Kyle, P., Williams, J.H., 2017. Measuring progress from nationally determined contributions to mid-century strategies. *Nat. Clim. Change* 7 (12), 871–874. <https://doi.org/10.1038/s41558-017-0005-9>.
- Jain, P., Bardhan, S., 2022. Does development assistance reduce climate vulnerability in developing countries? an empirical investigation. *Clim. Dev.* <https://doi.org/10.1080/17565529.2022.2065236>.
- Jernnäs, M., 2023. Governing through the nationally determined contribution (NDC): five functions to steer states' climate conduct. *Environ. Polit.* <https://doi.org/10.1080/09644016.2023.2192146>.
- Jin, I., Kim, Y., 2017. Analysis of the impact of achieving NDC on public climate finance. *Journal of Sustainable Finance and Investment* 7 (4), 309–334. <https://doi.org/10.1080/20430795.2016.1275934>.
- Khan, M.R., Munira, S., 2021. Climate change adaptation as a global public good: implications for financing. *Climatic Change* 167 (3–4), 50. <https://doi.org/10.1007/s10584-021-03195-w>.
- Khan, M., Robinson, S., ann, Weikmans, R., Ciplet, D., Roberts, J.T., 2020. Twenty-five years of adaptation finance through a climate justice lens. *Climatic Change* 161 (2), 251–269. <https://doi.org/10.1007/s10584-019-02563-x>.
- Klöck, C., Molenaers, N., Weiler, F., 2018. Responsibility, capacity, greenness or vulnerability? What explains the levels of climate aid provided by bilateral donors? *Environ. Polit.* 27 (5), 892–916. <https://doi.org/10.1080/09644016.2018.1480273>.
- Kono, D.Y., Montinola, G.R., 2019. Foreign aid and climate change policy: what can't the data tell us? *Polit. Govern.* 7 (2), 68–92. <https://doi.org/10.17645/pag.v7i2.1840>.
- Lamb, W.F., Minx, J.C., 2020. The political economy of national climate policy: architectures of constraint and a typology of countries. *Energy Res. Social Sci.* 64, 101429. <https://doi.org/10.1016/j.erss.2020.101429>.
- Lee, C.-C., Li, X., Yu, C.-H., Zhao, J., 2022. The contribution of climate finance toward environmental sustainability: new global evidence. *Energy Econ.* 111, 106072. <https://doi.org/10.1016/j.eneco.2022.106072>.
- Li, N., Shi, B., Wu, L., Kang, R., Gao, Q., 2022. Climate-related development finance, energy structure transformation and carbon emissions reduction: an analysis from the perspective of developing countries. *Front. Environ. Sci.* 9. <https://doi.org/10.3389/fenvs.2021.778254>.
- Mayer, B., 2023. Progression requirements applicable to state action on climate change mitigation under Nationally Determined Contributions. *Int. Environ. Agreements Polit. Law Econ.* <https://doi.org/10.1007/s10784-023-09614-w>.
- Mohan, P.S., 2022. Climate finance to support caribbean small island developing states efforts in achieving their nationally determined contributions in the energy sector. *Energy Pol.* 169. <https://doi.org/10.1016/j.enpol.2022.113208>.
- Mohan, P.S., 2023. Financing needs to achieve nationally determined contributions under the Paris agreement in caribbean small island developing states. *Mitig. Adapt. Strategies Glob. Change* 28 (5). <https://doi.org/10.1007/s11027-023-10062-9>.
- Munira, S., Bashar, R., Easher, T.H., Khan, M.R., 2021. Climate finance in the UNFCCC negotiations: bridging gaps with lessons learnt. In: Jakariya, Md N. I. Md (Ed.), *Climate Change in Bangladesh*. Springer International Publishing, pp. 1–24. https://doi.org/10.1007/978-3-030-75825-7_1.
- Nikolova, A., Ryder, H., 2021. Tackling the decisiveness deficit - how to enhance climate ambition of the Asia-Pacific countries? *Natl. Inst. Econ. Rev.* 258, 83–89. <https://doi.org/10.1017/nie.2021.43>.
- ODI, 2014. Climate finance: is it making a difference? A review of the effectiveness of multilateral climate funds. <https://cdn.odi.org/media/documents/9359.pdf>.
- Pauw, W.P., Klein, R.J.T., 2020. Beyond ambition: increasing the transparency, coherence and implementability of Nationally Determined Contributions. *Clim. Pol.* 20 (4), 405–414. <https://doi.org/10.1080/14693062.2020.1722607>.
- Pauw, W.P., Castro, P., Pickering, J., Bhasin, S., 2020. Conditional nationally determined contributions in the Paris Agreement: foothold for equity or Achilles heel? *Clim. Pol.* 20 (4), 468–484. <https://doi.org/10.1080/14693062.2019.1635874>.
- Piris-Cabezas, P., Lubowski, R.N., Leslie, G., 2023. Estimating the potential of international carbon markets to increase global climate ambition. *World Dev.* 167, 106257. <https://doi.org/10.1016/j.worlddev.2023.106257>.
- Plumer, B., 2022. Wealthy nations offer Indonesia \$20 billion to curb coal. *The New York Times*. <https://www.nytimes.com/2022/11/15/climate/indonesia-coal-agreement.html>.
- Qian, H., Qi, J., Gao, X., 2023. What determines international climate finance? Payment capability, self-interests and political commitment. *Global Public Policy and Governance*. <https://doi.org/10.1007/s43508-023-00062-5>.
- Romesburg, H.C., 2004. *Cluster Analysis for Researchers*. Lulu.com.
- Rumney, E., Sánchez, I.C., Dowdell, J., Nakayama, M., Murakami, S., Takenaka, K., 2023. Rich nations say they're spending billions to fight climate change. Some money is going to strange places. A Reuters Special Report. <https://www.reuters.com/investigates/special-report/climate-change-finance/>.
- Scandurra, G., Thomas, A., Passaro, R., Bencini, J., Carfora, A., 2020. Does climate finance reduce vulnerability in Small Island Developing States? An empirical investigation. *J. Clean. Prod.* 256. <https://doi.org/10.1016/j.jclepro.2020.120330>.
- Shishlov, I., Censkowsky, P., 2022. Definitions and accounting of climate finance: between divergence and constructive ambiguity. *Clim. Pol.* 1–19. <https://doi.org/10.1080/14693062.2022.2080634>.
- Suroso, D.S.A., Setiawan, B., Pradono, P., Iskandar, Z.S., Hastari, M.A., 2022. Revisiting the role of international climate finance (ICF) towards achieving the nationally determined contribution (NDC) target: a case study of the Indonesian energy sector. *Environ. Sci. Pol.* 131, 188–195. <https://doi.org/10.1016/j.envsci.2022.01.022>.
- The Economist, 2023. The choice between a poorer today and a hotter tomorrow. *Economist* 448 (9353), 54–56. <https://www.economist.com/finance-and-economics/2023/06/27/the-choice-between-a-poorer-today-and-a-hotter-tomorrow>.
- Tørstad, V., Seelen, H., Bøyum, L.S., 2020. The domestic politics of international climate commitments: which factors explain cross-country variation in NDC ambition? *Environ. Res. Lett.* 15 (2), 024021. <https://doi.org/10.1088/1748-9326/ab63e0>.
- van Asselt, H., Obergassel, W., Hall, C., Hermwille, L., Oberthür, S., Otto, S., Sanz, M.J., Xia-Bauer, C., 2023. Leveraging the Global Stocktake for effective sectoral climate governance. *PLOS Climate* 2 (6), e0000229. <https://doi.org/10.1371/journal.pclm.0000229>.
- Weikmans, R., 2023. The normative foundations of international climate adaptation finance. In: *The Normative Foundations of International Climate Adaptation Finance*. Cambridge University Press. <https://doi.org/10.1017/9781108943208>.
- Weiler, F., Klöck, C., 2021. Donor interactions in the allocation of adaptation aid: a network analysis. *Earth System Governance* 7. <https://doi.org/10.1016/j.esg.2021.100099>.
- Weiler, F., Sanubi, F.A., 2019. Development and climate aid to Africa: comparing aid allocation models for different aid flows. *Afr. Spectr.* 54 (3), 244–267. <https://doi.org/10.1177/0002039720905598>.
- Wu, X., Pan, A., Fei, R., 2021. Three-dimensional heterogeneity analysis of climate aid's carbon reduction effect. *J. Environ. Manag.* 289. <https://doi.org/10.1016/j.jenvman.2021.112524>.
- Xie, L., Scholtens, B., Homroy, S., 2023. Rebalancing climate finance: analysing multilateral development banks' allocation practices. *Energy Res. Social Sci.* 101. <https://doi.org/10.1016/j.erss.2023.103127>.
- Yeo, S., 2019. Where climate cash is flowing and why it's not enough. *Nature* 573 (7774), 328–331. <https://doi.org/10.1038/d41586-019-02712-3>.
- Zaman, T.S., 2023. The energy transition under the Paris agreement: assessing the existing normative directions. *Environ. Environmental Law and Policy Journal* 46 (2), 201–254. <https://environs.law.ucdavis.edu/volumes/46/2/Zaman.pdf>.
- Zhang, D., Managi, S., 2020. Financial development, natural disasters, and economics of the Pacific small island states. *Econ. Anal. Pol.* 66, 168–181. <https://doi.org/10.1016/j.eap.2020.04.003>.
- Zhao, J., Zhou, B., Li, X., 2022. Do good intentions bring bad results? Climate finance and economic risks. *Finance Res. Lett.* 48. <https://doi.org/10.1016/j.frl.2022.103003>.