Who needs it the most? Vulnerabilities towards tropical cyclones as catalysts for climate adaptation aid allocation

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Abstract

The impacts of climate change are unequally distributed across the globe, with countries in the Global South bearing the brunt of the adverse consequences. While developed nations have committed to assisting vulnerable countries in adapting to climate change, we know little about how this adaptation aid is allocated at the sub-national level. This study addresses this gap by tracing the allocation of multilateral adaptation aid projects in the Philippines to the provincial level. We disentangle and compare the effect of different sub-components of vulnerability - physical exposure, adaptive capacity, and past disaster-related fatalities - on the likelihood of receiving climate adaptation projects. To this end, we identify the purpose and location of all development projects sponsored by the World Bank and the Asian Development Bank in the Philippines from 2009 to 2019 and combine this data with highly detailed hazard exposure measures and cyclone fatalities estimates. Our findings indicate that neither physical exposure nor adaptive capacity are robustly correlated with receiving adaptation aid. However, we consistently find that provinces that have recently suffered from a high number storm-related fatalities are significantly more likely to attract adaptation projects. This study has important implications for our knowledge on how climate adaptation projects can succeed in contributing to the overall objective of climate justice.

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1 Introduction

Countries in the Global South require substantial assistance to build resilience against the consequences of climate change. Although their historical contribution to climate change, through relatively low levels of greenhouse gas emissions, is minimal compared to the industrialized countries of the Global North, they often bear the brunt of its most severe impacts. These regions are disproportionately affected by extreme weather events, such as droughts, storms, and floods, as well as environmental changes like desertification and rising sea levels (IPCC, 2022). Moreover, the socio-economic impacts of climate change are especially acute in the Global South, where limited resources hinder effective preparation and response to such crises (Formetta and Feyen, 2019; Jongman et al., 2015). As a result, populations that have contributed the least to global climate change often suffer the most from its consequences.

In response to this inequitable distribution of climate change impacts, the international community has made efforts to alleviate these disproportionate burdens. While countries in the Global North cannot reverse the damage caused, they can allocate resources and provide aid to those most exposed to environmental hazards. However, only providing humanitarian aid in the aftermath of natural disasters is not a sustainable approach. Consequently, adaptation aid has gained prominence as a strategy to help vulnerable communities adjust to increasing climate variability and change. Such initiatives focus on enhancing infrastructure to mitigate disaster risks, developing early warning systems, and promoting crop diversification to enhance resilience to weather extremes (UNFCCC, 2024).

To date, substantial funds have already been mobilized for climate adaptation, with more expected to be deployed in the future (Michaelowa and Sacherer, 2022). Given the scale of this financial commitment, scientific interest has grown regarding the allocation of adaptation aid (Doshi and Garschagen, 2020; Islam, 2022; Weiler et al., 2018). Policymakers, scientists, and civil society alike are asking which communities benefit most from this aid and whether the funds are reaching those most in need. While the Paris Agreement explicitly states in Article 9 that climate adaptation aid should prioritize 'those that are particularly vulnerable to the adverse effects of climate change'

(UNFCCC, 2015), systematic knowledge on how adaptation aid is allocated remains limited.

There are at least two key reasons for the persistence of this knowledge gap and the ambiguous findings in existing research. First, while studies have examined the allocation of climate adaptation aid overall, there is a pronounced lack of research at the sub-national level. Most studies focus on country-level allocation and fail to trace how adaptation aid is distributed within countries. Notable exceptions include the pioneering works of Barrett (2014) on adaptation finance in Malawi and Cisneros and Ilbay-Yupa (2023) on Ecuador. Hence, a majority of existing studies on adaptation aid do not provide insights into whether adaptation aid reaches the most vulnerable regions within countries. This gap is significant, as the benefits of adaptation are highly localized. To be effective, adaptation aid must reach the populations that need it most.

Second, defining 'need' in the context of adaptation finance is complex, as it encompasses multiple dimensions. To determine which populations are most vulnerable to climate change, various factors must be considered, leading to a range of concepts and operationalizations. One key dimension is physical vulnerability, which refers to populations' exposure to climate hazards. For instance, communities exposed to extreme precipitation and high wind speeds during tropical storms are at greater risk of harm. However, vulnerability is also shaped by a population's adaptive capacity - the ability to prepare for and respond to hazards (Adger, 2006). Societies with higher levels of economic development, strong state capacity, and functional institutions are better equipped to minimize or avoid the adverse consequences of extreme weather events (IPCC, 2022). Conversely, in regions with low adaptive capacity, even relatively weak storms can lead to severe socio-economic impacts. Therefore, overall vulnerability is a combination of physical exposure and adaptive capacity. Empirical operationalizations of need for adaptation finance vary depending on which of these facets of vulnerability is prioritized, potentially leading to different conclusions about whether aid is reaching those most in need (Klein, 2009).

This variability is evident in the findings of cross-country studies on adaptation finance, which use different indicators of vulnerability and yield contrasting results regarding aid allocation patterns. These studies provide inconsistent answers to the question of whether adaptation aid is effectively targeting the most vulnerable populations (Betzold and Weiler, 2017; Robinson and

Dornan, 2017; Saunders, 2019; Garschagen and Doshi, 2022). At the sub-national level, the issue is not just conflicting findings, but also the absence of comprehensive vulnerability assessments in existing analyses. While Barrett (2014) and Cisneros and Ilbay-Yupa (2023) account for physical exposure and adaptive capacity, neither incorporates a measure of overall vulnerability as a determinant of adaptation aid allocation. This omission is partly due to data limitations, as fine-grained information on localized impacts of climate hazards is often unavailable at the sub-national level.

Our study aims to address this gap by examining the sub-national allocation of multilateral development finance provided by the World Bank Group (WB) and the Asian Development Bank (ADB) in the Philippines from 2009 to 2019. The Philippines, one of the most hazard-prone countries globally, provides a valuable case study for understanding the distribution of adaptation aid at the sub-national level. Specifically, we investigate which sub-national vulnerabilities to tropical cyclones - the most frequent climate hazard in the Philippines - drive the allocation of adaptation projects. To assess whether adaptation aid targets vulnerable regions, we measure and compare different facets of need for cyclone adaptation funds.

Focusing on donor intent, we systematically coded individual development projects to determine whether they were explicitly intended for climate adaptation and identified the provinces where these projects were implemented. We matched this data with detailed information on precipitation and wind speed intensities during tropical cyclones as well as granular fatality data from official reports of the Philippine National Disaster Risk Reduction and Management Council. This allows us to isolate different potential determinants of adaptation aid allocation at an extremely detailed and, to the best of our knowledge, unprecedented level.

We theorize that different aspects of cyclone exposure and impact could serve as poignant signals that adaptation funds are especially needed in certain sub-national regions. We hypothesize that adaptation aid may be directed primarily toward regions with the highest physical exposure to cyclones, measured by precipitation and wind speed, as well as regions with the lowest adaptive capacity, indicated by poverty levels. Finally, we propose that aid allocation may also be driven by the severity of cyclone impacts, with provinces experiencing higher number of fatalities receiving more support, as this could be seen as a signal for high overall vulnerability.

Our findings indicate that physical exposure to tropical cyclones alone does not determine the allocation of adaptation aid. Additionally, regions with low adaptive capacity, as measured by economic development and poverty rates, do not receive significantly more adaptation projects. However, we find that adaptation finance is strongly influenced by cyclone-related fatalities, suggesting that policymakers respond to clear indicators of overall vulnerability. Provinces with higher fatality numbers from storms in the preceding two years are significantly more likely to attract adaptation projects funded by both the WB and ADB. This suggests that adaptation aid allocation within the Philippines aligns, at least partially, with the provisions of the Paris Agreement, provided that disaster-related fatalities are considered a valid indicator of vulnerability. However, if vulnerability is measured by exposure to hazards or lack of adaptive capacity, the most vulnerable regions do not necessarily receive the most adaptation finance.

2 Climate adaptation aid and aid adaptation logics

Climate change presents unique challenges to communities worldwide, influencing a wide range of critical policy decisions. The unprecedented complexity of this issue is reflected in academic research. The global response to climate change has spurred the development of specialized sub-fields across many disciplines, including the long-standing literature on development assistance (ODA) and humanitarian aid. Given the substantial increase in development aid dedicated to addressing climate-related challenges in recent years, a distinct sub-field has emerged, focusing on how developed countries assist others that lack the resources to address these challenges independently. In 2009, developed nations made a prominent commitment to mobilize USD 100 billion annually for climate mitigation and adaptation efforts (Michaelowa and Sacherer, 2022). These funds are primarily directed towards helping less developed countries reduce their greenhouse gas emissions (mitigation aid) and build resilience to the adverse effects of climate hazards (adaptation aid). Adaptation aid, in particular, is intended to support vulnerable populations who lack the means to protect themselves from climate-related risks. The majority of adaptation activities in developing countries are financed through bilateral and multilateral official development assistance (Barrett, 2022), with multilateral donors such as the World Bank prioritizing climate adaptation (WorldBank, 2019).

From a climate justice perspective, directing adaptation aid to the populations most in need appears self-evident. However, there are reasons to question whether such idealized distribution patterns are consistently followed. Although the field of climate finance and adaptation aid is relatively new, insights from the broader literatures on development and humanitarian aid suggest that aid allocation does not always align with stated objectives. Both development and humanitarian aid are intended to serve specific purposes - assisting the least-developed societies or alleviating suffering in the wake of humanitarian crises. Nevertheless, research indicates that these forms of aid are often influenced by factors beyond recipient need.

A well-established body of empirical literature demonstrates that recipient need is not always the most influential factor in determining development aid allocation (Briggs, 2017, 2018; Kotsadam et al., 2018; Öhler et al., 2019; BenYishay et al., 2022). Indeed, "there is reasonable consensus that foreign aid is often unrelated to the needs of the recipient country" (Qian, 2015, p. 280). Instead, aid often functions as a tool of foreign policy, used to promote the strategic interests of donor countries by primarily benefiting their allies or other politically or economically significant partners (the 'donor interest' model). Other theories suggest that aid may be used to reward recipients for certain behaviors, such as good governance or the development of democratic institutions (the 'recipient merit' model). Rather than consistently benefiting the poorest populations, studies show that aid allocation can be distorted by factors unrelated to need, including political patronage (Jablonski, 2014; Nunnenkamp et al., 2017; Rosvold, 2020), the influence of civil society organizations (Song et al., 2021), or the birthplace of political leaders (Dreher et al., 2019). Practical considerations, such as the feasibility of project implementation and ease of access, also play a role, with remote or difficult-to-reach regions often struggling to attract aid (Öhler et al., 2019; Briggs, 2021). Established aid networks and the institutional and administrative capacity of recipient regions are further important determinants of aid distribution (DiLorenzo, 2023).

In the context of humanitarian aid, a central question is whether more severe crises - typically measured by factors such as violent conflict or disaster-related fatalities - receive greater amounts of emergency funds than less severe events (Dellmuth et al., 2021; Fink and Redaelli, 2011; Fuchs and Öhler, 2021; Cheng and Minhas, 2021; Bommer et al., 2022). Interestingly, while some research emphasizes the role of humanitarian need in driving emergency aid allocation (Dellmuth et al., 2021), other studies highlight how donor self-interests can skew priorities (Fink and Redaelli, 2011; Fuchs and Öhler, 2021; Cheng and Minhas, 2021). At the sub-national level, biases have been found in the distribution of humanitarian aid, with funds disproportionately directed to the home regions of political leaders (Bommer et al., 2022) or specific social groups, such as castes (Eichenauer et al., 2020). As with development aid, practical factors like the presence of established aid infrastructure and the accessibility of affected regions also influence humanitarian aid allocation decisions (Francken et al., 2012).

Given that the broader literature on ODA and humanitarian aid demonstrates that designated aid does not always reach those most in need, several studies have begun to explore whether these findings extend to adaptation finance.

3 Does adaptation finance reach the ones most in need?

A growing body of literature examines the distribution of climate change adaptation aid, with several studies investigating whether bilateral and multilateral aid flows reach the most vulnerable countries, as stipulated by the Paris Agreement. A key challenge in addressing this question lies in the ambiguity surrounding the definition of climate vulnerability (Klein, 2009). The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as the 'the propensity or predisposition to be adversely affected' (IPCC, 2022, p. 43), but its multidimensional, multi-scalar, and time-varying nature makes it difficult to measure and operationalize (Birkmann, 2013; Naylor et al., 2020). As previously discussed, overall vulnerability results from the combination of physical exposure to hazardous events and the low adaptive capacity of affected populations. From a normative perspective, it remains unclear whether the allocation of adaptation aid should prioritize one factor over the other. Therefore, most studies addressing this issue employ a variety of measures to capture different aspects of vulnerability.

The selection of indicators and the specific vulnerabilities considered vary significantly across studies. Physical exposure is frequently measured by variables such as the population living below 5 meters above sea level or through extremes in precipitation and temperature. In contrast, adaptive capacity is often gauged using standard socio-economic performance indicators like GDP or income per capita, and, in some cases, more basic development measures such as child mortality rates. Furthermore, at the national level, several composite indices aim to encapsulate the various facets of vulnerability. Among the most prominent are the World Risk Index (WRI), the Notre-Dame Global Adaptation Index (ND-GAIN), and the Climate Risk Index (CRI). The WRI and ND-GAIN combine exposure to hazards with societal vulnerabilities to project overall vulnerability, whereas the CRI assesses past disaster impacts - measuring material losses and fatalities from previous climate-related disasters to score vulnerability. Not all studies incorporate all dimensions of vulnerability; for instance, while some works (Weiler et al., 2018; Betzold and Weiler, 2017) include physical exposure, adaptive capacity, and overall vulnerability separately, many cross-national studies (Robinson and Dornan, 2017; Han and Cheng, 2023; Robertsen et al., 2015) primarily consider overall vulnerability and adaptive capacity, without explicitly modeling physical vulnerability.

This body of research has produced diverse, and at times contradictory, findings on whether adaptation aid is allocated based on vulnerability. Several studies suggest that vulnerability - regardless of how it is measured - plays a minor role in determining the amount of adaptation assistance a country receives. For example, Stadelmann et al. (2014) argue that adaptation projects funded by the Adaptation Fund are driven more by cost-effectiveness concerns than by considerations of equity and vulnerability. Similarly, Robertsen et al. (2015) find that the distribution of bilateral adaptation aid in sub-Saharan Africa is influenced more by political and historical factors, such as a country's level of democracy, than by its vulnerability. Likewise, Doshi and Garschagen (2020) and Garschagen and Doshi (2022) conclude that vulnerability plays a limited role in the allocation of both bilateral adaptation aid and funds from the Green Climate Fund, with recipient countries' limited institutional capacity posing a major obstacle. In many cases, the most vulnerable countries lack the capacity to develop, plan, and implement adaptation projects that can attract international climate finance. Saunders (2019) also observes that, on average, the most climate-exposed countries do not receive more adaptation aid. These findings starkly contrast with those of Mori et al. (2019) and Robinson and Dornan (2017), who identify low adaptive capacity and overall vulnerability as strong predictors of the amount of bilateral adaptation assistance or Adaptation Fund support a country receives.

While these studies present contradictory findings, they generally exhibit internal consistency - either supporting or refuting the hypothesis that vulnerability influences adaptation aid allocation. However, this is not always the case. Some studies reveal more complex patterns. For instance, Weiler et al. (2018) Betzold and Weiler (2017) demonstrate that physical exposure to climatic hazards and overall vulnerability influence allocation decisions for bilateral adaptation aid from OECD countries, while adaptive capacity plays a lesser role. Similarly, Han and Cheng (2023) find that natural disaster risk is positively associated with the likelihood of receiving adaptation aid, while poor economic development - a proxy for low adaptive capacity - does not significantly attract more funds. Islam (2022), using the ND-GAIN index, also finds that higher vulnerability scores correlate positively with the distribution of adaptation finance, but GDP per capita alone is not a significant factor. Thus, adaptive capacity, when measured purely in economic terms, does not appear to be a decisive factor. These findings underscore the importance of distinguishing between different dimensions of vulnerability and their respective measures when assessing whether adaptation funds are distributed based on need.

Insights from the broader literature on Official Development Assistance (ODA) and humanitarian aid highlight the need to move beyond country-level analyses, as factors influencing aid allocation may differ at sub-national levels. Despite this, most studies on adaptation aid allocation have not traced its distribution within countries. This is a significant oversight, as the distribution of adaptation aid to vulnerable countries does not necessarily ensure that it reaches the most vulnerable populations within those countries. To date, only a few within-country studies have examined how adaptation aid is distributed at sub-national levels. For example, Barrett (2014), using ministry records from Malawi, finds that adaptation projects tend to be allocated to regions physically exposed to climate hazards but not to those that are socio-economically vulnerable. In contrast, Cisneros and Ilbay-Yupa (2023) find that adaptation aid in Ecuador responds to both physical exposure and socio-economic vulnerability, though historical exposure levels appear to have a greater influence than projections of future risk.

While both Barrett (2014) and Cisneros and Ilbay-Yupa (2023) account for physical vulnerability by measuring exposure to precipitation and temperature extremes and adaptive capacity through socio-economic data (e.g., poverty rates, life expectancy, unemployment), neither study considers overall vulnerability. This is a notable gap, as research like Weiler et al. (2018) and Betzold and Weiler (2017) has shown that results can be sensitive to the operationalization of vulnerability, with findings varying depending on the specific indicators used. Moreover, these two existing quantitative studies on sub-national adaptation aid yield opposing results regarding the role of low adaptive capacity in attracting adaptation finance. Thus, more nuanced insights are needed, particularly those that account for all dimensions of vulnerability. The following section will theorize how different forms of vulnerability to tropical cyclones manifest and propose a framework for assessing them.

4 Sub-national vulnerabilities requiring adaptation finance

Policymakers face varied challenges from climate change, and adaptation aid is intended to help mitigate these by preparing regions most at risk. However, climate impacts are unevenly distributed, with some sub-national regions facing more severe threats than others. Consequently, climate adaptation aid is often directed toward specific regions rather than being distributed uniformly across a country. Decisions about where to allocate these funds are typically made in collaboration between donors and national policymakers, as seen in the processes of multilateral organizations like the World Bank (Alcañiz and Giraudy, 2023). Most projects begin with a request by the recipient government to multilateral donors to assist them in achieving a development-related goal, i.e., in the case of adaptation finance to increase resilience against climate-related hazards (Masaki, 2018). Due to the informational advantage of country governments, multilateral donors typically rely on local institutions to ensure effective allocation decisions (Jablonski, 2014). The World Bank, for example, works in a so-called 'strategic dialogue' with recipient countries to identify the key development objectives and to create a 'Country Partnership Framework' which is the 'central tool that guides the [World Bank's] support for the member country's development program (WorldBank, 2014, p. 3). Individual projects themselves are proposed by the borrower. In consultation with a task team by the World Bank, both parties then jointly flesh out the proposed project, including its scope, components, financial structure, and possible risks, and the sub-national location(s) (WorldBank, 2015).

When allocating funds to prepare for climate change-related hazards such as tropical cyclones and deciding which sub-national regions of a country should be prioritized, multilateral donors and national policymakers often seek signals to guide their decisions. The Paris Agreement clearly states that adaptation aid should go to populations 'particularly vulnerable' to climate change (UNFCCC, 2015, Article 9). We assume that policymakers, especially those in multilateral development banks, will feel committed to this goal. Therefore, when addressing specific climate-related challenges, such as preparing for tropical cyclones and mitigating their impact, policymakers are likely to focus on the sub-national regions that need the most funds and support. However, obtaining clear information and reliable signals to guide these decisions at the sub-national level can be challenging.

While various vulnerability indicators exist at the cross-national level, such as the Climate Risk Index (CRI), World Risk Index (WRI), and ND-GAIN, these metrics are not readily available at the sub-national level. Furthermore, the concept of vulnerability is inherently ambiguous, and 'there is no objectivist truth in vulnerability assessment' (Klein and Möhner, 2011, p. 16). Consequently, any allocation of funds will necessarily be the result of socially constructed negotiations (Klein, 2009). Nevertheless, despite their limitations, existing vulnerability indicators can be useful as they attempt to capture this complex concept in a single measurement. At the sub-national level, however, policymakers also require signals to determine which regions should receive adaptation aid. In the absence of specific indicators reflecting certain aspects of vulnerability, policymakers may resort to simpler heuristics. So, what signals exist that can indicate whether a sub-national region needs adaptation funds to better prepare for tropical cyclones, and which can be easily observed?

Overall vulnerability is influenced by physical vulnerability - exposure to hazards - combined with low levels of societal resilience to withstand such hazards, or a lack of adaptive capacity. In the case of tropical cyclones, the first key component in determining which sub-national regions may require adaptation finance is relatively easy to define and observe: only provinces where cyclones occur can be physically vulnerable. Therefore, sub-national physical vulnerability to cyclones means being exposed to extreme precipitation and wind speeds. We propose that policymakers focus on regions that have been most intensely exposed to tropical cyclones when deciding where to allocate adaptation funds.

Hypothesis 1 *The more exposed a sub-national region is to tropical cyclones, the higher the number of climate adaptation aid projects it receives (i.e., hazard exposure and intensity matter).*

The second element is a lack of adaptive capacity, which cross-country studies often measure through low levels of economic development or high poverty rates. Less economically developed societies tend to be more susceptible to the negative effects of destructive hazards. It is important to note that wealth and economic development are not evenly distributed across a country and are often concentrated in a few sub-national regions. Therefore, it is plausible that policymakers prioritize the poorest sub-national regions in their adaptation efforts, assuming they have the lowest capacity to cope with tropical cyclones.

Hypothesis 2 *The lower the adaptive capacity of a sub-national region to tropical cyclones, the higher the number of climate adaptation aid projects it receives (i.e., poor economic development and poverty matter).*

However, physical vulnerability and adaptive capacity alone may not fully reflect overall vulnerability. What can be observed sub-nationally when both physical vulnerability and a lack of adaptive capacity to tropical cyclones coincide? We argue that overall vulnerability at the sub-national level can also be observed through the adverse impacts of hazards, such as the material and human losses resulting from tropical storms. Few events demonstrate the need for adaptation as clearly as deadly climate-related disasters. In this way, natural disasters not only provide readily available information about which locations are particularly vulnerable but also emphasize the urgency of addressing climate risks. In the absence of alternative indicators at detailed spatial scales, the local impacts of individual disasters should carry significant weight. We suggest that the effects of destructive disasters, particularly fatality numbers, serve as clear indicators of vulnerability at the sub-national level. These factors should significantly influence the allocation decisions of adaptation aid donors.

Destructive natural disasters also attract significant attention and global media coverage, with reports on impacts, death tolls, and economic damages spreading rapidly around the world. Therefore, when making decisions about aid allocation, recent major natural disasters serve as tangible reminders of climate change's impacts (Tversky and Kahneman, 1973, 1974). Furthermore, widespread human suffering often triggers an inherent desire to assist those in need. This concern is well illustrated by studies on humanitarian aid, which show that severe disasters frequently act as catalysts for aid deployment (Dellmuth et al., 2021; Fink and Redaelli, 2011; Fuchs and Öhler, 2021). These findings emphasize that policymakers are generally responsive to human suffering and are more likely to allocate resources to severely affected regions (Bommer et al., 2022; Eichenauer et al., 2020; Francken et al., 2012). In a study closely related to ours, Rosvold (2020) finds that provinces recently affected by disasters receive slightly more World Bank-sponsored development projects. Adaptation aid, with its focus on minimizing losses before they occur, is inherently linked to climate-related disasters. Therefore, the number of disaster victims should play an even more critical role in decisions about where to allocate adaptation funds.

Hypothesis 3 *The greater the detrimental impact of a tropical cyclone in a sub-national region, the higher the number of climate adaptation aid projects it receives (i.e., losses and fatalities matter).*

5 Data and empirical strategy

5.1 Empirical case

We test our hypotheses by analyzing the allocation of adaptation finance in the Philippines. Specifically, we examine how the distribution of multilateral adaptation projects across the 81 Philippine provinces from 2009 to 2019 correlates with physical exposure to tropical cyclones, socio-economic development, and cyclone-related fatalities. Our focus on within-country allocation offers two advantages. First, it provides analytical leverage by allowing us to hold broader contextual factors constant. By concentrating on one type of hazard in a single country, we can make a more precise comparison of how the same vulnerability measures differ between provinces. Second, determining vulnerability at the sub-national level is particularly challenging due to the lack of reliable and granular vulnerability indicators. Yet, because adaptation aid tends to have highly localized impacts, ensuring it reaches vulnerable populations is crucial. However, as the research on development aid suggests, significant allocation biases may exist within countries. Even when aid flows to the most vulnerable countries, it does not necessarily reach the most vulnerable populations within them (Barrett, 2022). Given the limited research tracing adaptation finance to the local level, we still have little understanding of the extent to which this occurs.

The Philippines is an interesting and suitable case to test our theoretical argument for a number of reasons. Located along the Pacific Typhoon Belt and the Ring of Fire, the country is regularly exposed to different natural hazards, making it one of the most disaster-prone countries in the world. While the people of the Philippine have developed considerable skills and capabilities for living with these hazards (Bankoff, 2002), climate change poses a new and additional challenge for the country. As a middle-income country, the Philippines is a recipient of substantial amounts of development aid. Due to its exposed nature, the country does not only attract general development projects but also a meaningful number of specialized climate adaptation projects. Understanding how this aid is distributed and where adaptation projects go within the country is thus of considerable interest in itself. Finally, the Philippines also has a very institutionalized approach to disaster risk reduction with detailed documentations about the precise impact of various disasters. After significant events, in-depth disaster reports with nuanced information are issued which allow us to identify the precise extent to which a province is affected by individual natural disasters.

We focus on tropical cyclones because they are one of the most destructive climate-related hazards (WMO, 2021). Furthermore, while there is seasonal variation over the year, with storms occurring most frequently in certain months, an accurate forecast of when and where exactly a tropical cyclone will make landfall is only possible within days or hours before. Yet, this has potentially beneficial implications for causal inference. Since, conditional on covariates and fixed effects, the exact timing and location of a tropical storm within the Philippines is plausible exogenous to adaptation projects, the humanitarian impact of a given storm should largely be idiosyncratic and not related to other potential drivers of adaptation aid, which otherwise could confound our results. While we thus focus on tropical cyclones for empirical reasons, in principle, our hypothesis should hold for many other kinds of climate-related disasters as well.

We analyze projects by two of the most important sponsors of development projects in the Philippines: the World Bank and the Asian Development Bank. In 2019, the ADB funds accounted for 26% of the country's portfolio of official development assistance while resources by the WB made up 20%, which makes them the second and third most important sponsors behind Japan (39%) (NEDA, 2020). Moreover, the WB and the ADB are the most prominent providers of adaptation finance globally (Barrett, 2022). Furthermore, focusing on projects sponsored by multilateral developments banks makes this research more comparable to insights from the broader development aid allocation literature, which has also often focused on WB projects when analyzing sub-national allocation patterns. Finally, both the WB and the ADB provide extensive project documentations which enable us to identify climate adaptation projects and their exact locations.

5.2 Adaptation aid

Climate adaptation aid is challenging to differentiate from other forms of development assistance, particularly due to the absence of a universally agreed-upon definition regarding which projects qualify as adaptation aid (Donner et al., 2016; Barrett, 2022). Essentially, there are two different approaches for identifying adaptation finance. One approach considers whether the aid is explicitly designated for climate adaptation purposes, emphasizing the donor's intention as the distinguishing factor between adaptation and other types of development aid. Another approach focuses on the project's functionality, examining whether its specific outputs can effectively mitigate the societal vulnerability to climate change hazards. All projects fulfilling this criteria would then count as adaptation aid (Barrett, 2014; Donner et al., 2016).

The two approaches to identifying projects do not always yield the same results. For example, many development projects can be argued to reduce vulnerability to climate change, even if they were not originally designed for that purpose. For instance, infrastructure projects aimed at improving roads to enhance market access in rural areas may also simultaneously decrease vulnerability to storms, as a well-functioning road network can facilitate evacuation and emergency responses during disasters. In other cases, the first approach might result in more projects being labeled as adaptation because donors are known to sometimes earmark development projects for adaptation that are either totally unrelated to climate adaptation (Michaelowa and Michaelowa, 2011; Weikmans et al., 2017) or even maladaptive (Eriksen et al., 2021).

Officially, both the OECD DAC and the multilateral development banks rely on a combination of these two approaches for labeling adaptation projects. They require an explicit statement of intent of the donor as well as a clear and direct link between specific project activities and vulnerability reduction (African Development Bank et al., 2022, p. 1; OECD DAC, 2024). Otherwise, they will not consider a project adaptation finance. Still, previous research has shown that there exist substantial discrepancies between the labeling choices of donors and the actual content of these projects (Barrett, 2022; Toetzke et al., 2022). Hence, to avoid working with potentially misreported data and replicating documentation biases, we manually classified adaptation projects ourselves by analyzing all available project documents of all WB and ADB sponsored development projects in the Philippines from 2009-2019. In total, we coded 151 projects of which we classified 58 as adaptation. The ADB had slightly more adaptation projects (35 out of 83) than the WB (23 out of 68).

Our focus was exclusively on the stated purpose of a given project and not on the factual suitability of project outputs for vulnerability reduction. We opted for this approach primarily due to practical considerations. There is a lot of ambiguity in what constitutes a 'clear and direct link'. Moreover, thoroughly evaluating this criterion would require detailed technical knowledge about the efficacy of the different policy interventions, touching upon areas such as governance capacity, insurance markets, and physical infrastructure. Due to a lack of comprehensive expertise, we concentrated on the much more straightforward indicator of donor intent to avoid potentially ill-informed coding decisions.

We regard adaptation intent to be given when a project states that it aims to alleviate any adverse consequence of climate change for the people of the Philippines. For some projects this is obviously the case, for example the 'Climate Change Adaptation Program' sponsored by the WB in 2010. Often, development aid is given for disaster risk reduction projects. We considered them as resources for adaptation when they are aimed at increasing resilience towards climate-related natural hazards such as storms and floods. This often involves the improvement of physical infrastructure like roads, dams and bridges. For example, the 'Metro Manila Flood Management Project' project in 2017 was aimed at upgrading the drainage and pumping system in Manila.

Additionally, we identified to which provinces a project went. We repeatedly came across projects that had sub-locations in multiple provinces. In these cases, we counted each provinces as receiving an adaptation project. As our analysis focuses on the decision-making process, we assign each project to the year of its approval date, which represents the end of this decision-making process. If a project is deployed to the central government or otherwise affects the entire country, we consider all provinces as receiving an adaptation project. Figure 1 shows the cumulative distribution of all climate adaptation projects sponsored from 2009 to 2019 by the WB and the ADB. As can be seen on the maps, adaptation projects are not evenly distributed across the country but cluster in the central Visayan Islands and in Mindanao in the South. Luzon in the north of the country receives comparatively fewer projects. Further summary statistics for the number of adaptation projects and all other variables can be found in Table A1 in the Appendix. Additionally, Figure A1 in the Appendix displays the distribution of adaptation aid over time, where, perhaps contrary to expectations, there is no clear or increasing pattern discernible.

5.3 Physical exposure

The danger from tropical cyclones stems from a combination of both high wind speeds and extreme amounts of precipitation (Yonson et al., 2018). To obtain a meaningful measure of physical exposure to tropical cyclones, we thus follow Tennant and Gilmore (2020) and calculate the population-weighted hazard exposure, which is a combination of both wind speed and rainfall. In order to do this, we first used the Willis Research Network Global Tropical Wind Footprint dataset (Done

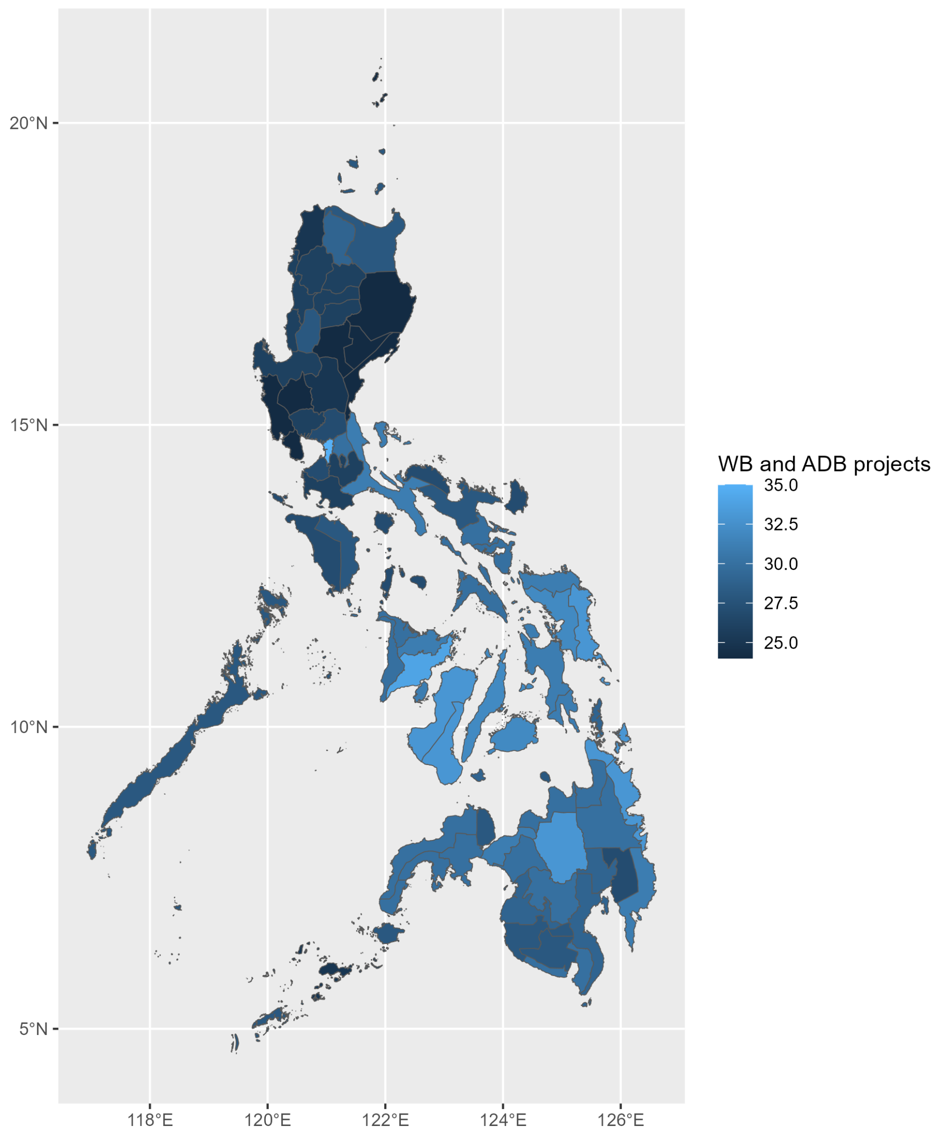

Figure 1: Climate adaptation projects by the World Bank and the Asian Development Bank 2009 to 2019

et al., 2022) to identify all major tropical cyclones that made landfall or passed by the Philippines. Then, for each individual storm, we calculated the product between wind speed measured in 3x3km grid cells and the number of people living in each cell and aggregated this to each province. Wind speed data come from (Done et al., 2020), which combine parametric Willoughby wind field models with terrain effects from geographic features, such as the topographic relief and coastlines of the area. Accounting for terrain is important in the Philippines as mountains and steep hills can have a substantial influence on the wind speed experienced in a specific location (Done et al., 2020). The wind speed data represent the 1-minute maximum sustained wind speeds 10m above the surface in each 3x3km grid cell. The result is a very fine grained measure of wind exposure that is a linear function of the wind speed and the number of people exposed to that amount of wind.

We repeat the same procedure using the amount of rainfall during the tropical cyclone. We rely on Multi-Source Weighted-Ensemble Precipitation rainfall data, a high resolution (0.1 degrees) dataset that incorporates information from gauge, satellite, and reanalysis data (Beck et al., 2019). We use the 24h maximum rainfall of each month in which a storm made landfall and again combine this measure with number of people living in each cell as described above. As the rainfall data is only available at a resolution of 11x11km, we first resample the population data to the same resolution before aggregating the product to each province. Population numbers are from the WorldPop project (worldpop.org) and we use the unconstrained top-down model for 2008 at a resolution of 1x1km. We use the year 2008 to guard against potential post-treatment bias where population dynamics might be influenced by tropical cyclones and their impacts. The final hazard exposure variable is the natural logarithm (+1) of the sum of the population-weighted wind and rain exposure.

5.4 Adaptive capacity

We follow the literature and rely on socio-economic development to proxy adaptive capacity (Mori et al., 2019; Weiler et al., 2018; Weiler and Klöck, 2021; Islam, 2022). We use two separate variables: GDP per capita and poverty severity. GDP per capita is a measure for the overall wealth of a province that comes from (Kummu et al., 2018). Because these are only available until 2015, the last observed value of each province is carried forward. Because of its aggregated nature, however, GDP per capita is only an imperfect proxy for poverty that does not take the distribution of wealth within a society into account. For example, a rich province with a relatively high GDP per capita could still be home to a significant number of poor people if wealth and income are distributed very unequally. Hence, we also include poverty severity, which is a measure for how many households fall how far below the poverty line. We use data come from the Philippine Statistics Authority which reports the squared poverty gap (the Foster-Greer-Thorbecke(2) index) for the years 2009, 2012, 2015, and 2018. We interpolate the missing years.

5.5 Disaster fatalities

Available data sources of sub-national disaster impacts, such as the International Disaster Database (EM-DAT) or the Geocoded Disaster Database (GDIS) (Rosvold and Buhaug, 2021), do not only suffer from a significant amount of missing data on this variable (Jones et al., 2022), but also offer no information about the precise distribution of fatalities across provinces. In other words, EM-DAT and GDIS only provide overall fatality estimates for each storm but no information about how many people died in which province. Since most tropical cyclones in the Philippines affect more than one province, this dataset is not optimal for our analysis.

Hence, we compiled a novel province-level dataset of storm-related fatalities in the Philippines from 2009 to 2019. For each storm in our dataset, we gathered the available situation reports from the National Disaster Risk Reduction and Management Council of the Philippines (NDRRMC). The NDRRMC is responsible for disaster risk reduction in the Philippines and protecting the people of the Philippines during natural hazards and related emergency situations. The situation reports issued by the NDRRMC provide detailed information on storm impacts, ranging from estimates of economic damages over affected populations to casualties numbers. Based on these reports, we coded the number of storm-related fatalities for each individual province, counting both missing and dead persons. Since the distribution of disaster deaths is highly skewed to the right and we expect the marginal effect of one additional disaster-related fatality to decline with increasing disaster deaths, we transform the number of disaster deaths (+1) using the natural logarithm.

5.6 Controls

We control for several factors that could potentially affect both the likelihood of receiving an adaptation project and the fatality numbers of tropical cyclones. First, as more populous provinces might both suffer from more fatalities and receive more projects, we include yearly population estimates from the WorldPop project using the top-down unconstrained version.

Another potential confounding variable that has been found to be influential for aid allocation is the absorptive capacity of the recipient, which refers to the ability of recipients to make productive use of the funds (Barrett, 2014; Garschagen and Doshi, 2022). For the sub-national distribution of adaptation aid, the state capacity of the provincial governments seems to be particularly important in this regard. Well functioning government institutions might be able to be relatively more successful in lobbying for aid projects because they can better demonstrate their capabilities of planning and implementing projects. At the same time, they might be also be able to reduce disaster impact through more effective disaster risk reduction policies (Tennant and Gilmore, 2020). Accordingly, we account for provincial government's state capacity by including the share of the provincial government's income that comes from tax revenue. The ability to raise taxes is one of the core pillars of the state and an often used indicator in the state capacity literature (Hanson and Sigman, 2021). We collected these data from the statistics of the Philippine Bureau of Local Government Finance.

Next, we also control for armed conflict, as violence is intimately related to the allocation of aid (Öhler and Nunnenkamp, 2014; Bezerra and Braithwaite, 2016) and, at the same time, might make populations more vulnerable to the impacts of climatic hazards (Peters, 2021). Additionally, armed conflicts are often based on some underlying grievances or discontent of the local population with the national government. The two ongoing armed conflicts in the Philippines, for example, are between the government on the one hand and communist insurgents and Muslim separatists, respectively, on the other hand. It stands to reason that national policy-makers might be hesitant to allocate aid projects to the respective strongholds of their adversaries. Thus, by controlling for armed conflict, we are able to capture the most important dimensions of political or ethnic favoritism that might bias the allocation decisions. We use the number of conflict events as recorded by the Georeferenced Event Dataset from the Uppsala Conflict Data Program (UCDP GED) (Sundberg and Melander, 2013). We include only events where at least the province is known. These data contain events from armed conflicts with at least 25 battle-related deaths in a calendar year and individual events enter the data when there is at least one direct death reported (Högbladh, 2021).

Finally, we also control for already existing aid networks by including the rolling sum of total development aid projects in a given province. Such already established aid networks lower transaction costs for additional adaptation projects (Barrett, 2014; Weiler and Klöck, 2021) and could also reduce susceptibility to cyclone impacts. We include the combined rolling sum of all projects from the WB and the ADB for which we have location information. For the WB, we have information for both climate and non-climate adaptation projects from 1995 to 2019. For the period from 1995 to 2014 we partly relied on the AidData project (AidData, 2017). Additionally, we geo-coded all WB projects in the Philippines ourselves for the remaining years. For the ADB, we coded the location for all climate adaptation projects from 2009 to 2019.

5.7 Empirical strategy

Using these data, we build a province-year panel data set that consists of 81 provinces over 11 years and estimate fixed effects Poisson regression models that regress the number climate adaptation projects on our measures of vulnerability. We lag the vulnerability measures by one year as the process of reacting to changing vulnerability levels might take some make. To avoid post-treatment bias, we also lag all control variables by one year. We focus on the number of projects received over alternative measures, such as the total amounts committed, because there is typically no way to determine the amounts of aid that go to each province. In our main analyses, we combine the number of WB and ADB projects into one single variable as we do not expect significant differences between the two donors. Furthermore, in background interviews, officials from the WB reiterated that there exists some basic coordination between between the two donors in the Philippines. Nonetheless, we also repeat our analyses for each donor separately.

Even though our control variables should enable us to account for the most important alternative explanations for allocation decisions, there still might exist unobserved confounding variables on the level of the provinces. We thus include province-level fixed effects to capture any unobserved heterogeneity. Importantly, the fixed effects are able to capture the baseline level of vulnerability of each province. Thus, we focus on changes in vulnerability *within* provinces. This makes us fairly confident that any effect of our vulnerability measures on the likelihood of receiving an adaptation project is not confounded by other underlying unobserved characteristics of a province. Furthermore, we also include year fixed effects to account for unobserved shocks that affect all provinces simultaneously.

We prefer a Poisson model over a Negative Binomial model - the main alternative for count data - because the latter is not a true fixed effects model (Allison and Waterman, 2002; Ferreira et al., 2013), and it is crucial that we account for all unobserved province effects. Additionally, the fixed effect Poisson estimator has strong robustness properties (Wooldridge, 1999). For example, its parameter estimates are consistent even in the case of overdispersion, which in turn can be corrected using robust standard errors (Wooldridge, 2010, p. 762 ff.). Hence, we cluster standard errors on the level of the provinces in all models.

6 Results

Table 1 presents our main findings. The table shows the results for the relationship between the number climate adaptation projects sponsored by the World Bank and the Asian Development Bank and the different vulnerability measures. In Models 1 to 3, we introduce our measures for physical hazard exposure, adaptive capacity, and disaster fatalities separately before combining them all in Model 4. As can be seen, only some of the vulnerability measures are significantly associated with the number of adaptation projects. First, the coefficients for our measure of physical hazard exposure are statistically insignificant in Models 1 and 4. Exposure to extreme levels of wind speed and precipitation in the past year is not associated with the number of adaptation projects. This means that provinces that have been exposed to tropical cyclones do not receive more adaptation projects, refuting Hypothesis 1.

This finding is notable as it stands in contrast to the two other quantitative studies on subnational adaptation aid allocation. Both Barrett (2014) and Cisneros and Ilbay-Yupa (2023) found that physical exposure was a significant predictor of adaptation aid. This does not seem to be the case for tropical cyclones in the Philippines. One important difference is that we also account for the actual hazard impacts by incorporating disaster-related fatalities. It is unclear whether these differences stem from different country and donor contexts, from different climate hazards or from the fact that include a measure of hazard impact. It needs more research to further disentangle these effects.

Table 1: Allocation of climate adaptation projects (WB and ADB)

Dependent Variable:	Nr of adaptation projects			
Model:	(1)	(2)	(3)	(4)
Variables				
Hazard exposure (log)	-0.05			-0.07
	(0.04)			(0.04)
GDPpc		0.00		0.00
		(0.00)		(0.00)
Poverty		0.00		-0.01
		(0.01)		(0.01)
Disaster deaths (log)			0.02***	0.03***
			(0.01)	(0.01)
Existing aid network	-0.06***	-0.06***	-0.06***	-0.06***
	(0.00)	(0.00)	(0.00)	(0.00)
Conflict events	0.00***	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)
Population	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Tax revenue (%)	-0.78	-0.75	-0.72	-0.65
	(0.53)	(0.53)	(0.50)	(0.51)
Fixed-effects				
Province	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	810	810	810	810

Clustered (Province) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Next, our findings regarding our measures of adaptive capacity - GDP per capita and poverty - are similarly statistically insignificant. Neither GDP per capita nor poverty severity is significantly associated with the number of adaptation projects in Model 2 or Model 4. This resonates with the findings of Barrett (2014) who also finds only limited influence of adaptive capacity but goes against the results of Cisneros and Ilbay-Yupa (2023) who finds that socio-economic vulnerability in Ecuador is correlated with adaptation aid. One caveat of our empirical strategy is that we only look at within province changes in our independent variables. Socio-economic development, however, tends to vary across rather than within provinces and the limited within-variation might not be meaningful enough to prompt allocation decisions. Again, we need more research in even more contexts, ideally with better measures of socio-economic vulnerability.

Finally, there is a statistically significant positive relationship between the number of disaster-related fatalities in a given province in the previous year and the number of adaptation projects that a province receives (Model 3 and 4). When particularly deadly cyclones struck sub-national regions in the Philippines, a significantly higher number of adaptations aid projects were deployed to these provinces in the following year. Overall, this lends some strong support for Hypothesis 3. Policymakers seem to only react to cyclones when they cause fatalities but not to extreme wind speed and precipitation measure per se.

The substantial size of this effect, however, is modest. One useful way to illustrate the effect size is to compare the model's predictions of the number of adaptation projects across varying levels of disaster deaths holding the other predictors at their observed mean values. For the Model 4 in Table 1, the predicted number of adaptation projects in a given province-year is 0.61 when a province experiences zero disaster deaths in the previous year. However, when we move from zero to 6333 disaster deaths - the largest number that we see in our sample (the Province of Leyte in 2013) - the predicted number of adaptation projects rises to 0.767. This means moving from the observed minimum to the observed maximum value of disaster deaths increases the expected number of adaptation projects by 0.15, holding all other variables at their mean. This is a modest effect when considering that the maximum number of adaptation projects per province-year in our sample is only seven.

We also ran several additional model specifications to check the robustness of our results. First, we report results separately for the WB and the ADB (Appendix Table A2 and Table A3). Here, the results largely corroborate the findings from the combined dependent variable. Interestingly, the adaptation projects by the ADB show a statistically significant *negative* relationship with hazard exposure, indicating that provinces that have been exposed to tropical cyclones receive less ADB-sponsored adaptation projects. Next, we dropped the year fixed effects and instead modeled a linear time trend (Table A4 in the Appendix) as there might be some concern about heterogeneous treatment effects biasing our two-way fixed effects models (De Chaisemartin and D'Haultfœuille, 2020). We find evidence for a statistically positive effect of physical hazard exposure and GDP per capita, providing some nuance to the conclusions regarding Hypotheses 1 and 2. Notably, the results of our disaster fatality measure remains unchanged. Note, however, that the results of these models might be biased by unobserved global shocks. Finally, we re-ran the hazard exposure models without including population as a control variable, as there might be concerns about collinearity because our hazard measure is already weighted by population. The results in Table A6 are virtually identical to our main specifications.

As a next step, we conducted a placebo test, in which we checked whether our measure of climate vulnerability affects the allocation of traditional development projects that are unrelated to climate adaptation. If this would be the case, it would cast doubt on our assumption that it is the specific climate vulnerabilities that attract climate adaptation aid and our measure of vulnerability might only pick up general trends in aid allocation. As Table A5 in the Appendix shows, however, this seems not to be the case. In fact, none of the vulnerability measures is statistically significantly associated with non-climate aid projects. Critically, this reinforces the assumption that donors and policymakers allocate adaptation aid according to specific climate-related indicators and do not give these projects simply to the same recipients of traditional development aid.

To validate the plausibility of our quantitative findings, we paid particular attention to how the two donors justify their allocation decisions in the project descriptions. Both the WB and the ADB make explicit references to recent deadly hazards in several of their project documentations. For example, Typhoon Yolanda was an extraordinarily devastating and deadly storm which hit the

Philippines in 2013. In response, the World Bank freed additional resources to assist the affected populations. Notably, these projects included more than simple humanitarian emergency aid and had an explicit capacity-building component that was aimed at 'improving the preparedness and capacities for disaster risk management and response' (WorldBank, 2013, p. 6). Similar strategies could be identified for the ADB which also initiated new projects after the fatal catastrophe of Typhoon Yolanda. While these newly funded projects were, of course, intended to assist some of the 74 particularly hard-hit communities in the Visayan Islands in rebuilding, the focus was explicitly on 'building back better' and thereby improving resilience to future disasters (Bank, 2016). The project documents repeatedly emphasized that more effective emergency project management, improved coordination, monitoring, and reporting were among the central aims of the project. That both donors make explicit connections between climate adaptation projects and past cyclone fatalities reinforces the confidence that our result are not spurious statistical associations but represent an actual empirical pattern of how decisions for the sub-national allocation of adaptation projects are made.

7 Conclusion

While international climate finance is growing rapidly, it still lags behind the sums that were promised by developed nations. Funds for adaptation, which should help communities prepare better for future climate hazards and make them more resilient, have been particularly insufficient (Roberts and Weikmans, 2022; Toetzke et al., 2022; CPI, 2023). While there exist a debate whether the available adaptation finance actually reaches the most vulnerable *countries* (Betzold, 2015; Doshi and Garschagen, 2020; Weiler et al., 2018), we know little about how decision-makers distribute adaptation funds at the sub-national level.

In this study, we examined the regional allocation of multilateral climate adaptation aid in the Philippines, focusing on different sub-national vulnerability measures. We theorized that adaptation aid may be allocated to regions that physically exposed to tropical cyclones, to provinces that have a low adaptive capacity, as well as to regions that recently suffered significant fatality numbers from tropical cyclones. To test these hypotheses, we manually coded the stated purpose and the locations of all development projects sponsored by the World Bank and the Asian Development Bank in the Philippines. We combined this data with highly granular wind speed and precipitation data and detailed information about climate-related natural disaster fatalities that we gathered from official situation reports provided by the National Disaster Risk Reduction and Management Council. Our results indicate that the distribution of adaptation projects seems to be unrelated to physical hazard exposure as well as adaptive capacity. However, we find a positive association between adaptation finance and the number of fatalities from recent tropical cyclones. Provinces that have suffered from destructive tropical cyclones attract a significantly higher number of adaptation project in the two following years. This underscores the importance of carefully defining and operationalizing vulnerability, when evaluating an equitable distribution of climate finance (Klein, 2009; Islam, 2022).

Our findings constitute an important contribution to the nascent research agenda examining the allocation of international adaptation finance (Weiler et al., 2018; Doshi and Garschagen, 2020; Islam, 2022). While previous research has mainly looked at the cross-national distribution of climate finance and analyzed in how far it follows vulnerability concerns, we focus on the sub-national level and use detailed measurements of different sub-components of vulnerability to provide much-needed evidence for how adaptation aid is distributed *within* receiving countries. By manually coding all aid projects by the two most important multilateral donors in the Philippines, we add to the pioneering work of Barrett (2014) and Cisneros and Ilbay-Yupa (2023) by analyzing the sub-national allocation of adaptation aid in new contexts and with new measures. Notably, when accounting for actual hazard impacts, our findings indicate that hazard exposure is not significantly associated with adaptation aid. This underscores that we need significantly more research on how different aspects of vulnerability are (un-)able to attract international adaptation finance.

An important open question pertains to the generalizability of our findings - both to other countries and to other donors as well as to other hazards. In this study, we were only able to investigate the allocation of adaptation aid of two donors in a single country. Because part of the proposed causal channel runs through the involvement of national policy-makers in the allocation decisions, a couple of features of our case might be important in this regard. First, the WB and the ADB cooperate considerably with national policy-makers due to the informational advantage of the latter. Furthermore, we only analyzed the exposure to tropical cyclones. While we do not think that cyclones are unique in this aspect, more research is needed on other types of natural hazards.

From a policy perspective, studying the allocation of climate adaptation aid is crucial because doing so can help verifying in how far the international community complies with its commitments of the Paris Agreement to aid populations that are 'particularly vulnerable' to climate change (UNFCCC, 2015, Article 9). Currently, there is a lack of systematic knowledge regarding the distribution of climate finance (Weikmans and Roberts, 2019; Roberts et al., 2021). If one considers disaster-related fatality numbers a valid indicator of climate vulnerability, our results may be interpreted somewhat optimistically. Yet, if only these severe and fatal manifestations of vulnerability attract adaptation aid, it implies that preceding warning signs are potentially being overlooked. This is underscored by our mixed findings with regard to socio-economic vulnerability and hazard exposure. In this regard, our study reiterates the need of an agreed-upon operational definition of vulnerability, as otherwise it is almost impossible to hold donors accountable to their promises (Khan et al., 2020; Islam, 2022). Similarly, the conceptual boundaries of climate adaptation aid need to be more precisely delineated. Without a consistent framework for categorizing adaptation aid, estimating its amounts and understanding the factors driving its allocation remains difficult (Shishlov and Censkowsky, 2022).

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8 Appendix

Table A1: Descriptive statistics.

Statistic	N	Mean	St. Dev.	Min	Median	Max
Climate adaptation projects (total)	891	2.600	1.463	0	3	7
Climate adaptation projects (WB)	891	1.011	0.959	0	1	4
Climate adaptation projects (ADB)	891	1.589	1.156	0	2	6
Hazard exposure	891	553.463	195.152	169.905	531.886	1,472.261
GDP per capita	891	4,940.361	1,541.167	2,210.423	4,612.504	14,941.330
Poverty severity	891	2.243	1.945	0.0001	1.743	11.563
Disaster deaths	891	14.689	218.564	0	0	6,333
Existing aid network	891	13.247	5.578	1	13	27
Conflict events	891	1.897	5.345	0	0	112
%Tax revenue	891	0.106	0.110	0.003	0.068	0.682
Population	891	1,165,945.000	1,514,524.000	14,185.700	719,659.300	12,586,661.000

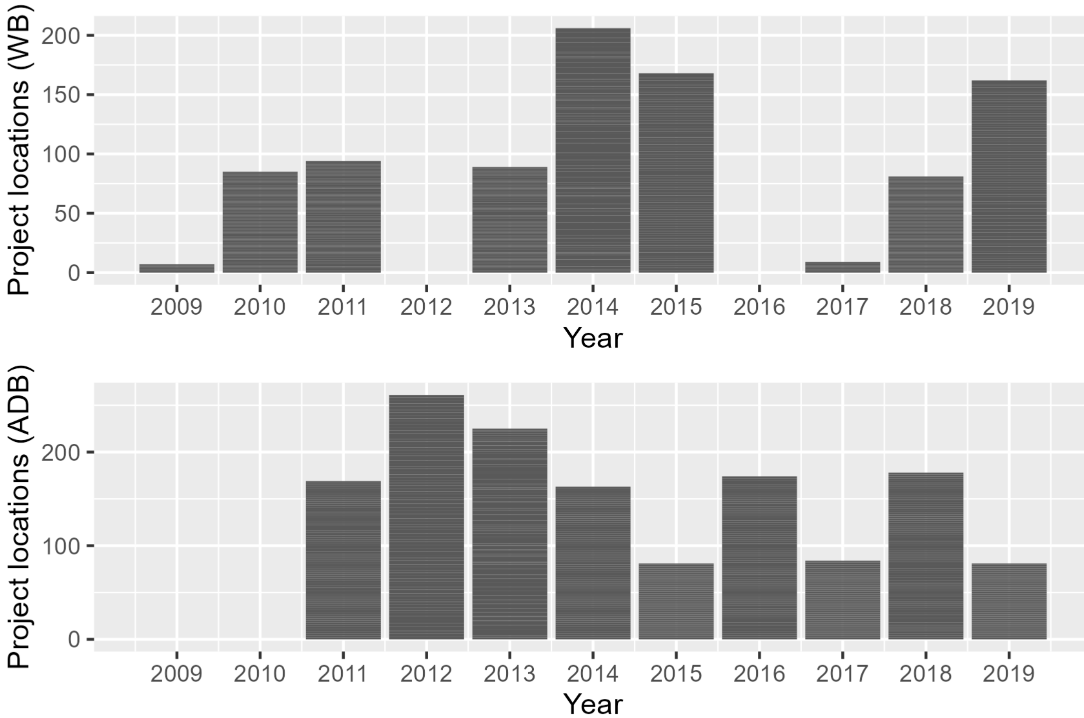

Figure A1: Adaptation aid over time.

Table A2: Allocation of climate adaptation projects of the World Bank

Dependent Variable:	Nr of adaptation projects			
Model:	(1)	(2)	(3)	(4)
Variables				
Hazard exposure (log)	0.00			-0.02
	(0.07)			(0.08)
GDPpc		0.00		0.00
		(0.00)		(0.00)
Poverty		0.01		0.01
		(0.01)		(0.01)
Disaster deaths (log)			0.03**	0.03**
			(0.01)	(0.01)
Existing aid network	-0.05***	-0.05***	-0.05***	-0.05***
	(0.01)	(0.01)	(0.01)	(0.01)
Conflict events	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Population	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Tax revenue (%)	0.13	0.19	0.20	0.27
	(0.60)	(0.61)	(0.56)	(0.56)
Fixed-effects				
Province	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	648	648	648	648

Clustered (Province) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A3: Allocation of climate adaptation projects of the Asian Development Bank

Dependent Variable:	Nr of adaptation projects			
Model:	(1)	(2)	(3)	(4)
Variables				
Hazard exposure (log)	-0.10**			-0.12**
	(0.05)			(0.05)
GDPpc		0.00		0.00
		(0.00)		(0.00)
Poverty		-0.02		-0.02
		(0.01)		(0.01)
Disaster deaths (log)			0.03**	0.03***
			(0.01)	(0.01)
Existing aid network	-0.07***	-0.07***	-0.07***	-0.07***
	(0.01)	(0.01)	(0.01)	(0.01)
Conflict events	0.01***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Population	0.00*	0.00	0.00*	0.00*
	(0.00)	(0.00)	(0.00)	(0.00)
Tax revenue (%)	-1.57*	-1.61**	-1.53*	-1.44*
	(0.80)	(0.81)	(0.79)	(0.79)
Fixed-effects				
Province	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	729	729	729	729

Clustered (Province) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A4: Allocation of climate adaptation projects with linear time trend

Dependent Variable:	Nr of adaptation projects			
Model:	(1)	(2)	(3)	(4)
Variables				
Hazard exposure (log)	0.33***			0.29***
	(0.08)			(0.08)
GDPpc		0.00**		0.00***
		(0.00)		(0.00)
Poverty		0.02		0.02
		(0.02)		(0.02)
Disaster deaths (log)			0.07***	0.05***
			(0.02)	(0.02)
Existing aid network	-0.08***	-0.08***	-0.08***	-0.08***
	(0.01)	(0.01)	(0.01)	(0.01)
Conflict events	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Population	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Tax revenue (%)	2.27**	2.44**	2.70**	2.14**
	(1.11)	(1.12)	(1.15)	(1.08)
Time trend	0.12***	0.10***	0.11***	0.10***
	(0.01)	(0.01)	(0.01)	(0.01)
Fixed-effects				
Province	Yes	Yes	Yes	Yes
Fit statistics				
Observations	810	810	810	810

Clustered (Province) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A5: Allocation of non-climate projects

Dependent Variable:	Nr of non-adaptation projects			
Model:	(1)	(2)	(3)	(4)
Variables				
Hazard exposure (log)	0.02			0.03
	(0.02)			(0.03)
GDPpc		0.00		0.00
		(0.00)		(0.00)
Poverty		0.00		0.00
		(0.01)		(0.01)
Disaster deaths (log)			0.00	0.00
			(0.00)	(0.00)
Existing aid network	-0.01**	-0.01**	-0.01***	-0.01**
	(0.00)	(0.00)	(0.00)	(0.00)
Conflict events	0.01	0.01	0.01	0.01
	(0.00)	(0.00)	(0.00)	(0.00)
Population	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Tax revenue (%)	-0.53**	-0.52**	-0.52**	-0.55**
	(0.25)	(0.26)	(0.25)	(0.26)
Fixed-effects				
Province	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	810	810	810	810

Clustered (Province) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A6: Allocation of climate adaptation projects (no population)

Dependent Variable:	Nr of adaptation projects			
Model:	(1)	(2)	(3)	(4)
Variables				
Hazard exposure (log)	-0.05			-0.07
	(0.04)			(0.04)
GDPpc		0.00		0.00
		(0.00)		(0.00)
Poverty		0.00		-0.01
		(0.01)		(0.01)
Disaster deaths (log)			0.02***	0.03***
			(0.01)	(0.01)
Existing aid network	-0.06***	-0.06***	-0.06***	-0.06***
	(0.00)	(0.00)	(0.00)	(0.00)
Conflict events	0.00***	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)
Tax revenue (%)	-0.73	-0.75	-0.72	-0.59
	(0.53)	(0.53)	(0.50)	(0.51)
Population		0.00	0.00	
		(0.00)	(0.00)	
Fixed-effects				
Province	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	810	810	810	810

Clustered (Province) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*