Climate Finance and Adaptation Intervention Needs in Malaysia

Charles River Economics Labs

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1 Team and Project Overview

1.1 Charles River Economics Labs

Established in 2022, the Charles River Economics Labs (CREL) is a 501(c)(3) organization dedicated to providing pro-bono economic research support to NGOs and nonprofit organizations. CREL is student-run and consists of branches at Harvard, Stanford, and the University of Chicago. Previous project partners include the United States Department of Transportation and the Brookings Institute. Our organization retains support from a Board of Advisors which includes Andrei Shleifer and Karen Dynan.

1.2 Project Overview

This project was commissioned for the Khazanah Research Institute in Malaysia. With COP29 is coming up at the end of 2024, countries like Malaysia need to come up with nuanced asks around climate finance. This paper aims to use public datasets on past global climate financing and adaptation interventions to evaluate the financial burden that is placed on Malaysia as a result of climate change.

The paper focuses on two major topics: (1) analyzing climate flows to Malaysia and similar countries and (2) evaluating the financial costs of adaptation measures targeted to rising sea levels. The first half of the paper focuses on a review of public datasets that detail past climate finance funding by recipient countries, using techniques like mean comparisons and visualizations to establish a baseline amount for funding that Malaysia should expect. The second half of the paper focuses on a literature review of previous projects within the space of rising sea level adaptation as well as of previous research done at a global scale on estimating these costs.

2 Results in Brief

3 Policy Background & Literature Review

3.1 Global Climate Initiatives

Most governments seek to address climate change through a combination of adaptation and mitigation strategies. Adaptation strategies focus on modifying procedures and systems to decrease the effect of climate change on people's livelihoods. Examples include developing early-warning and emergency-preparedness systems for climate-related natural disasters, building resilient health infrastructure, and improving food security. Mitigation strategies focus on limiting climate change. According to the Paris Climate Agreement, the goal of climate change mitigation is to limit global temperature rise to 1.5℃ over pre-industrial levels. Mitigation strategies include transitioning from

coal power to renewable energy and preventing deforestation.

Global climate summits, such the annual Conference of the Parties (COP) held by the United Nations, emphasize the importance of international cooperation in combating climate change. Specifically, a pillar of the Summary of Global Climate Action at COP28 is ensuring that higher-income countries provide resources and funding to aid lower and middle-income countries. Countries also have varying vulnerabilities. Southeast Asia is considered very susceptible to the effects of climate change, with millions of people living in densely populated coastal areas that will be impacted by rising sea levels and an increased frequency of natural disasters. Mobilizing international funding is a complex issue, often involving multilateral development banks as facilitators of public and private funding.

3.2 Overview of Climate Financing

In 2014, global climate financing reached an estimated total of $391 billion, comprising $148 billion (38%) from public sources and $243 billion (62%) from private investment Matthew J. Kotchen (2017). Multilateral climate institutions such as the Global Environmental Facility, Climate Investment Funds, and Green Climate Fund, alongside development banks like the World Bank and IMF, are increasingly prioritizing climate finance Matthew J. Kotchen (2017). Investment in climate adaptation and resilience has been lagging significantly on the global scale. The majority of climate finance has been raised and expended within national borders, although developed countries pledged in 2015 to increase the scale of their provision of climate finance in developing countries to at least $100 billion per year by 2020, a commitment that has yet to be met Matthew J. Kotchen (2017).

Climate financing consists of various forms of investments. Green bonds are fixed-income investments that funnel funds into green projects. They are typically issued by governments, but increasingly issues by corporations. Biodiversity financing, or financing for the purpose of increasing biodiversity, typically comes from both public and private means. To incentivize private investment, biodiversity investments can be packaged with farmland productivity to increase returns to investors. Social impact investing aims to finance business ventures that have a positive social impact. These tend to be most impactful in disadvantaged urban areas, but due to discrimination these communities rarely receive such investments.

3.3 Public and Private Investment in Climate Financing

Climate financing can be drawn from private or public sources. Over the past decade, governments, particularly in developed countries, and private sector entities have invested heavily in renewable energy and tangential non-tradable sectors of the economy, such as urban and road transport Baysa Naran et al. (2022). Public sector support was crucial in scaling renewable energy investment by enabling technology cost reduction and by providing incentives such as time-bound subsidy

mechanisms Baysa Naran et al. (2022). Mobilizing larger pools of private funds has become a central objective in most climate finance strategies. However, only 1.6% of adaptation finance came from private sources in 2018 World Bank Group et al. (2021). Key barriers to attracting private finance for adaptation agendas include lack of country-level climate risk data, limited clarity on government capital investment gaps, and low perceived or actual returns on investment World Bank Group et al. (2021). For instance, private cost-benefit analyses of climate projects often overlook non-market benefits, leading to socially desirable yet unprofitable projects being left unfunded unless supplemented by a net-positive subsidy World Bank Group et al. (2021). The need to increase private-sector investment in climate adaptation is particularly dire in the Asia-Pacific region, where fiscal space is significantly constrained by public debt accumulated during the pandemic and the cost of issuing sustainable debt is relatively high Cheng Hoon Lim et al. (2024).

A variety of strategies have been suggested and adopted to boost private investment in climate finance. International bodies such as the United Nations call for greater absorption of risk on the climate finance balance sheets of developing countries, as well as increased international climate data sharing and stronger on-the-ground presence from international finance actors Independent High-Level and Expert Group on Climate Finance (2022). Public-private partnerships (PPPs) and green investment banks (GIBs) are crucial for mobilizing private capital for green infrastructure development Dharish David and Anbumozhi Venkatachalam (2018). They represent collaborations between public and private financial institutions to jointly provide green finance in a cost-effective manner. While PPPs focus on delivering public infrastructure services through partnerships, GIBs aim to leverage private finance for green investments. Japan has emerged as an international leader in the implementation of PPPs and GIBs for cross-institutional climate finance progress Dharish David and Anbumozhi Venkatachalam (2018). Since March 2016, Japan has established over 500 PPP projects covering energy, water, waste, cultural centers, and medical facilities Dharish David and Anbumozhi Venkatachalam (2018). Many of these projects are managed by the Green Innovation Fund, which also works with government entities to develop climate change countermeasure taxes and international clean infrastructure investments Dharish David and Anbumozhi Venkatachalam (2018).

3.4 Climate Financing in Southeast Asia

Southeast Asia receives merely 5% of climate financing across Asia and the Pacific. Most of this financing comes from development finance institutions (DFIs), which are government-owned institutions dedicating to supporting private sector projects in developing countries. The primary Asia-specific DFIs are the Asian Development Bank (ADB) and the Asian Infrastructure Investment Bank (AIIB). Established in 1966, ADB has 68 member countries, 49 of which are from Asia and the Pacific. In its Strategy 2030 Plan, ADP announced that it aims to become Asia's "climate bank", pledging to double its annual climate financing, reaching $100 billion by 2030. In 2023, ADP provided $5.5 billion for climate change mitigation and $4.3 billion for climate change

adaptation, in the form of loans and grants to member countries. Established in 2015, AIIB 109 member countries and has also prioritized climate financing. In their 2022 Annual Report, AIIB committed to making climate financing 50% of total lending by 2025. As of 2022, 81% of its climate funding was focused on climate change mitigation, while 19% was focused on adaptation.

Climate financing in the Asia-Pacific is primarily structured around sustainable debt issuance rather than equity funds. As a whole, the Asia-Pacific region contributed to 25% of the global growth in sustainable debt issuance, with advanced economies and emerging market developing economies (EMDEs) evenly split. While sustainability-linked loans and bonds dominated advanced Asian economies, green bonds, largely driven by Chinese investor appetite, constituted the primary share of EMDE issuance. Public sources also dominate over private sources of capital, and Asia is currently the world's leading producer of carbon offsets. There remains a significant financing gap of at least $800 billion annually between current inflow and the amount necessary for climate mitigation and adaptation investments. Since its "greenmium" percentage currently sits at the negatives, meaning that investors are unlikely to accept green bonds over conventional bonds due to uncompensated higher risk and profit loss, the region faces a particular challenge in executing more favorable pricing for sustainable debt issuance.

Private and philanthropic climate financing support in Asia is critically lacking due to insufficient awareness and understanding of implementable solutions, compounded by the lack of structured data collection and mismanagement of expectations regarding the delivery timeline World Economic Forum and Philanthropy Asia Alliance (2023). Only 2% of global philanthropic giving is directed toward preventing climate change, with even less of this funding addressing climate issues specific to Asia World Economic Forum and Philanthropy Asia Alliance (2023). There is an opportunity for change in the form of philanthropic-Public-Private Partnerships (PPPPs). PPPPs are seen as essential for solving the climate and nature crisis and are especially promising in Southeast Asia, a region that has deep roots in philanthropy. One key example of a successful PPPP for climate financing in the Asia-Pacific region is the Resilient Cities Network, an urban resilience network working on more than 4,000 projects to bring nature-based solutions to cities vulnerable to climate change across 40 countries World Economic Forum and Philanthropy Asia Alliance (2023). The Network is supported by city governments as well as the Rockefeller Foundation and other private actors World Economic Forum and Philanthropy Asia Alliance (2023). Other relevant PPPPs include Clime Capital and the Just Energy Transition Partnership (JET-P), both programs that provide multilateral funding to accelerate transitions to clean energy in countries such as Vietnam, Indonesia, and the Philippines World Economic Forum and Philanthropy Asia Alliance (2023).

4 Descriptive of Methods and Data

4.1 Analysis on Global Climate Finance Landscape

4.1.1 Data

Public data on climate finance flows is available from the OECD. We were able to extract two datasets from the OECD sources, one on public development-related climate funding and another on private climate funding.

The public finance dataset contains information on 24093 funding transactions from 2021. Each transaction includes both donor and recipient countries, as well as the funded amount.

4.1.2 Regressions

4.2 Analysis on Adaptation Financing in Malaysia

4.2.1 Literature Review

5 Global Climate Finance Analysis Results

5.1 OECD Public Financing

5.1.1 Descriptive Analysis

The Organisation for Economic Co-operation and Development (OECD) is an international organization composed of 38 member countries, established to promote economic growth, prosperity, and sustainable development. The OECD provides a platform for its member countries to compare policy experiences, seek answers to common problems, identify good practices, and coordinate domestic and international policies. Its members are predominantly high-income countries with a high Human Development Index and are regarded as developed countries. The organization conducts economic analysis, collects data, and publishes reports, which forecasts economic trends and developments.

According to the OECD Public Financing dataset, the public finances are spread through different sectors as shown in the Figure 1.

Figure 1 presents an overview of the distribution of public funding across the sectors, derived from the OECD dataset. The horizontal bar chart illustrates the total amount allocated to each sector, reflecting the relative financial emphasis placed on different areas of public interest and infrastructure.

The sectors receiving the most substantial public funding include Energy, Transport and Storage, Agriculture, Water Supply, and General Environment Protection. These sectors are critical for economic stability and growth, underscoring their prioritization in public funding. This data is important for understanding the priorities set by policymakers in the allocation of public resources.

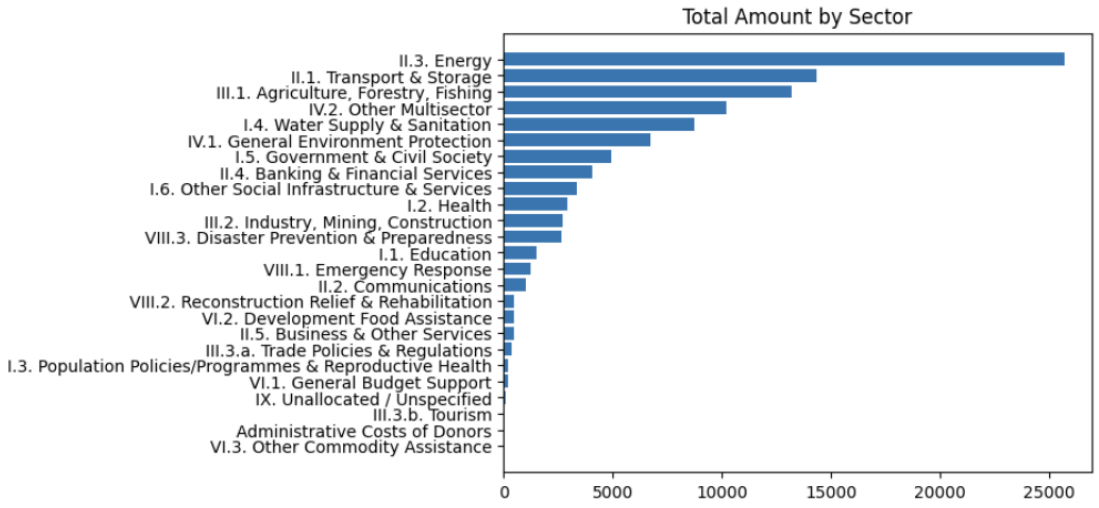

Figure 1: Funding distribution per sector

The analysis of sectoral funding distribution assists in identifying both the focus areas and potential gaps within current public funding strategies, providing a basis for more informed decision-making and policy adjustments aimed at achieving balanced economic and social development.
Another perspective to visualize the distribution of the public funds is to look at the regions receiving the funds, as shown in Figure 2.

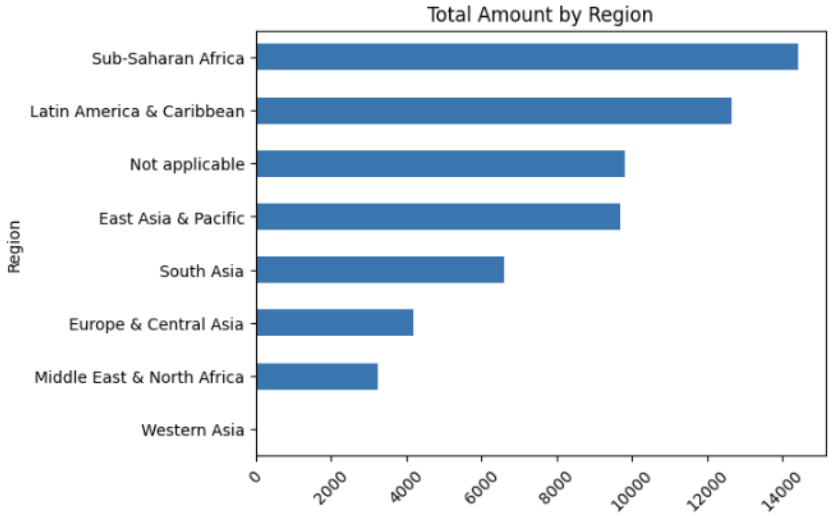

Figure 2: Funding distribution per region

Figure 2 illustrates the distribution of public funding by region, using data extracted from the OECD dataset. The chart shows that Sub-Saharan Africa receives the highest level of funding, significantly more than other regions, which underscores a focused approach towards development challenges in this area. Latin America and the Caribbean also receive substantial funding, reflecting the ongoing economic and social development efforts in these regions.

The category labeled "Not applicable" contains a considerable amount of funding. This could indicate funds that are set aside for global or unspecified projects, or that are not restricted to a specific geographical area, suggesting a flexibility in addressing global challenges as they arise.
Other regions such as East Asia and Pacific, South Asia, and Europe and Central Asia receive moderate to substantial funding, aligning with their respective developmental needs and the strategic interests of funding agencies. In contrast, regions like Middle East and North Africa and Western Asia receive relatively lesser funding, which might reflect geopolitical considerations, the current economic policies, or the perceived urgency of needs in these areas.
This non-uniform distribution of public-funds is important for analyzing how funding priorities may shift in response to regional stability, economic opportunities, and developmental needs.
Another criteria to look for in the distribution of the public funds is the countries' income, as shown in Figure 3.

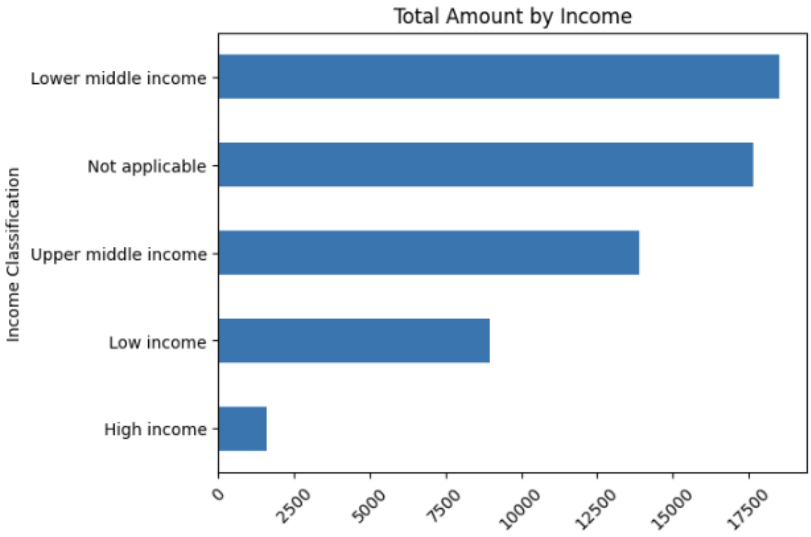

Figure 3: Funding distribution per income category

Figure 3 provides a visualization of public funding distribution across different income classifications, sourced from the OECD dataset. The data reveals a substantial emphasis on lower middle-income countries and upper middle-income countries, which receive the most significant portion of funding. This prioritization could indicate a strategic aim to bolster the economies that are on the cusp of transitioning to a higher income status but may still face considerable developmental hurdles.
The category "Not applicable" accounts for a large share as well, suggesting that there are substantial funds allocated to programs or initiatives that are not specific to any single income classification or perhaps serve a more global purpose. High-income countries receive the smallest allocation, indicating that the primary focus of public funding is towards nations with more significant developmental requirements.
This distribution pattern helps in understanding the alignment of financial aid with developmental

strategies and economic classifications. It shows an emphasis to support emerging economies and reflects a conscious allocation toward countries where funding can have a substantial impact on poverty reduction and sustainable growth

Looking more specific in the upper middle-income countries, the following distribution of public funds across countries is shown in Figure 4.

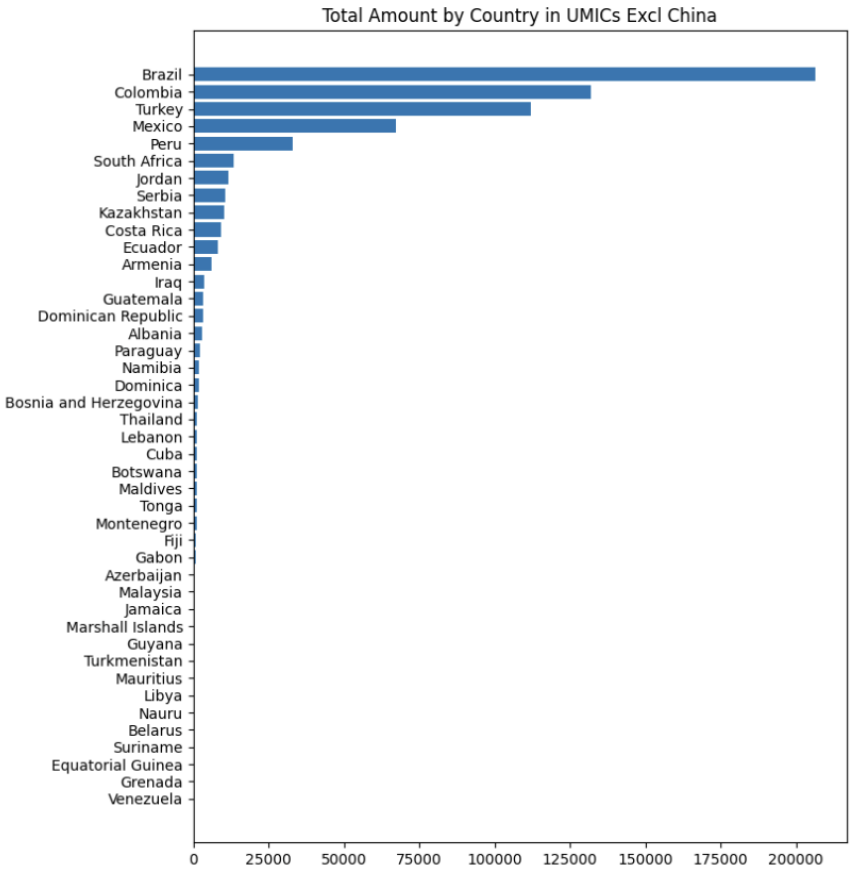

Figure 4: Funding distribution across UMIC

Figure 4 presents a breakdown of public funding allocations to upper middle-income countries (UMICs), excluding China. The distribution pattern reflects the diverse developmental strategies tailored to the individual economic and social contexts of these countries.

The visualization underscores a strategic allocation of resources that may correlate with a multitude of factors including the countries' size, population, regional influence, and specific developmental needs. It also raises questions about the criteria and policies driving these financial decisions and the impact of such allocations on the development of upper middle-income countries.

Specific to Malaysia, it is worth mentioning that it receives less funding in comparison to countries with a similar income profile and similar demands and geographical position. The distribution across sectors of public funds received by Malaysia is shown in Figure 5.

Figure 5 illustrates the distribution of funding across sectors in Malaysia, using data sourced from

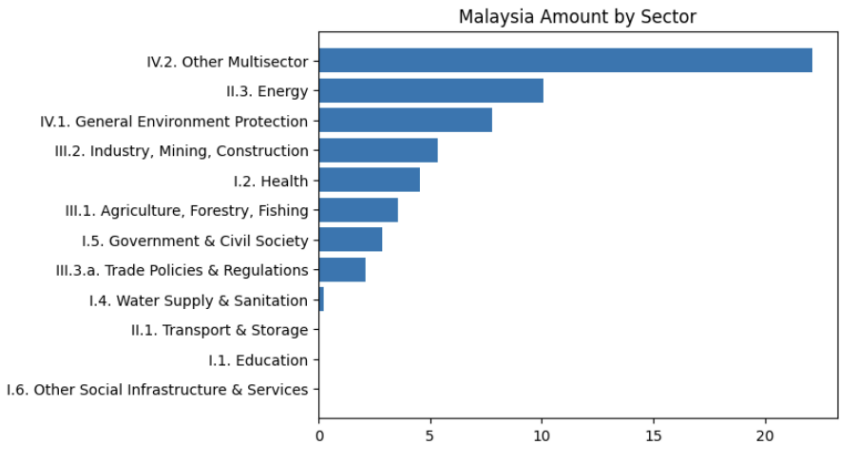

Figure 5: Funding distribution across UMIC

an OECD dataset. While the distribution generally aligns with global funding patterns, notably, Malaysia exhibits a significant emphasis on "General Environment Protection." This sector receives more funding compared to many other nations, indicating a strong national commitment to environmental sustainability. Such prioritization suggests that Malaysia is actively investing in initiatives aimed at preserving its natural resources and mitigating the impacts of climate change.

5.1.2 Regressions

A key component of our research involved analyzing the relationship between total climate funding received by countries and variables such as OECD income classification, recipient region, and financial mechanism. Here, we used regression analysis to quantify the aforementioned correlations, using data merged from the OECD Mobilization and OECD Public Finance datasets.

Table 1 reveals a stark disparity in climate funding across regions with America as the reference category. All regions received significantly less funding than America, as indicated by the negative coefficients and their high statistical significance (p ¡ 0.001). The most substantial deficits are observed in the Caribbean and Central America, Far East Asia, and South of Sahara. The adjusted R-squared value is exceptionally low, hinting at the presence of other influential variables not accounted for in the model that are responsible for the observed funding distribution. Regardless, Table 1 raises questions about the equity and adequacy of climate finance, especially since regions such as Africa, South of Sahara, and South and Central Asia, which are often highly vulnerable to climate change, appear to receive significantly less funding relative to the baseline.

	(1) Total Public Funding
Africa	8374.9****
	(4.47)
America	14118.3****
	(5.19)
Asia	4839.4*
	(1.94)
Caribbean & Central America	-3474.1****
	(-5.11)
Europe	4756.0
	(.)
Far East Asia	-19463.3**
	(-2.08)
Middle East	0
	(.)
North of Sahara	-25095.2
	(-1.38)
Oceania	365.3
	(.)
South & Central Asia	-8356.4**
	(-2.18)
South America	-12513.4**
	(-2.15)
South of Sahara	-411.9
	(.)
_cons	530.5
	(.)
Number of observations	16409.00
Adjusted R-squared	0.06

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Table 1: Total public funding vs. Recipient region in 2021

	(1) Total Public Funding
LDCs	0
	(.)
LMICs	2429.5****
	(1.40e+10)
MADCTs	260.1****
	(1.52e+09)
UMICs	-259.0****
	(-4.14e+08)
_cons	314.7****
	(1.84e+09)
Number of observations	16409.00
Adjusted R-squared	0.02

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Table 2: Total public funding vs. OECD country income classification in 2021

The regression analysis of total climate funding as related to OECD country income classification in Table 2 displays a significant positive relationship for Lower and Upper Middle-Income Countries, which receive more funding compared to the reference category of Least Developed Countries. The t-statistics associated with the coefficients — especially for LMICs (1.40e+10) and UMICs (-4.14e+08) — demonstrate that the relationships are not only statistically significant but also robustly estimated. The result for a category labeled MADCTs is not statistically significant, indicating no clear association with climate funding changes. However, the model as a whole explains a very small portion of the variance in climate funding (2%).

	(1) Total Public Funding
Debt instrument	0
	(.)
Equity and shares in collective investment vehicles	-12367.5**
	(-2.18)
Grant	-26289.0****
	(-7.89)
_cons	26513.9****
	(7.96)
Number of observations	16403.00
Adjusted R-squared	0.12

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Table 3: Total public funding vs. Financial mechanism in 2021

Table 3 highlights a negative correlation for both equity and shares in collective investment vehicles and grants with robust statistical significance, as underscored by t-statistics of -2.18 and -7.89, and corresponding p-values indicating rejection of the null hypothesis at well below the 0.1% threshold. Surprisingly, the coefficient for equity and shares suggests that an incremental unit of investment in these vehicles is associated with a decrease of $12,367.5 in total climate funding, whereas the grant variable suggests an even more substantial decrement of $26,289 per unit increase, potentially signaling an inverse funding allocation or displacement effect. The model's explanatory power is modest, with an Adjusted R-squared of 0.12. The high significance of the constant term also suggests a baseline level of climate funding potentially driven by factors outside the financial mechanisms considered.

5.2 Climate Funds Financing

5.2.1 Descriptives

The Climate Funds Update (CFU) Climate Funds dataset has tracked multilateral climate funds since 2003. Figure 6 illustrates that from 2003 to 2021, the amount of funding approved by climate funds has steadily increased, peaking at over $3.5 billion from 2020-2021. Approved funding decreased sharply from 2021-2022. This anomaly likely stems from a delay in updating the Climate Funds dataset. CFU gathers data from fund websites, official reporting from funds, and public documents, then corresponds with fund managers to verify this information. Funding approved in 2022 may not have been fully reported or verified.

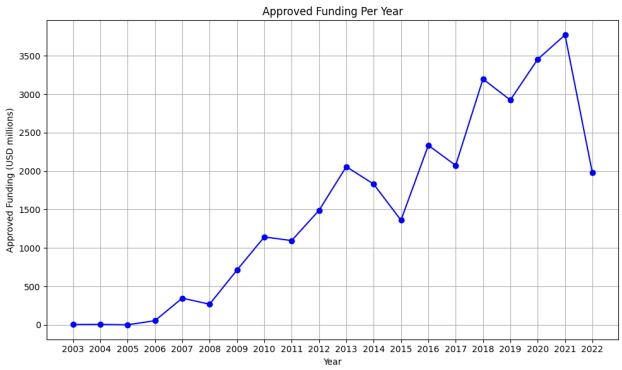

Figure 6: Approved Funding Per Year

According to Figure 7, lower and upper middle income countries are allocated the largest share of country-specific funding. This statistic does not necessarily indicate a bias toward these income classifications. Figure 8 shows approved funding averaged across the number of countries in each income group. By this metric, low income and lower middle income countries are allocated the most funding, at $172 million and $171 million of funding per country. Upper middle income countries are allocated about $128 million of funding per country, and high income countries are allocated about $10 million of funding per country. Low income and lower middle income countries are most

in need of climate change-related funding, so this data indicates that climate funds are targeting their financial resources for maximum impact.

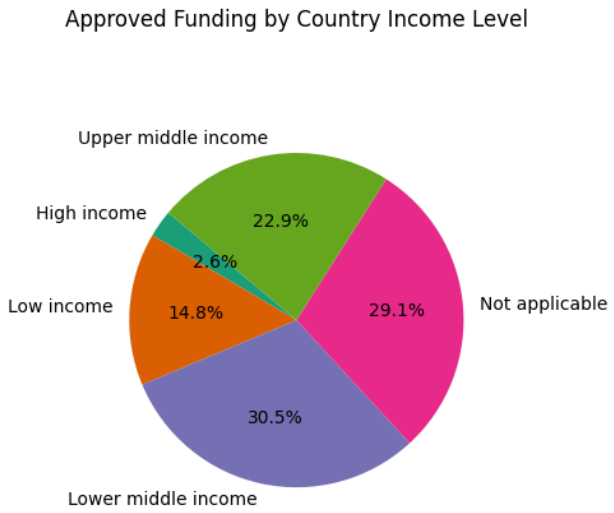

Figure 7: Approved Funding By Country Income Level

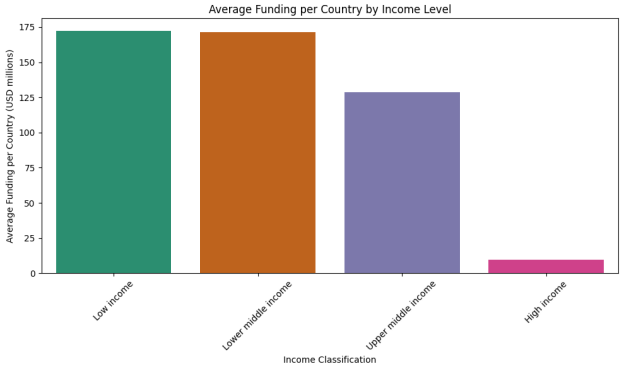

Figure 8: Average Approved Funding Per Country By Income Level

Funding is classified as either pledged or deposited. Pledged funding represent monetary support that a donor has offered, through a verbal or written commitment, to a specific fund. Deposited funding represent funding that has been transferred from donors to the fund's account. Figure 9 indicates that 87.63% of pledged funding has been deposited. Once deposited funding has been allocated toward a program or project, it is labelled as approved funding.

However, Figure 10 demonstrates that less than 40% of approved funding has been disbursed. Funding is classified as disbursed funding when it is proven to have been spent through a program or project. CFU notes that the status of financing reported in the Climate Funds dataset is dependent

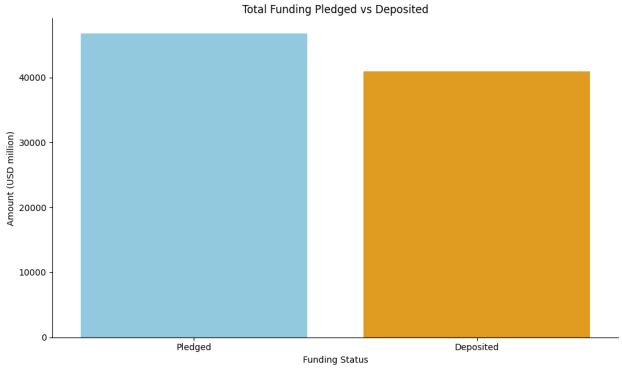

Figure 9: Total Funding Pledged and Deposited

on the availability of information from funds and initiatives. Therefore, the low disbursal figure may be due to the actions of funding contributors and recipients or a lack of updated information on the status of approved funds.

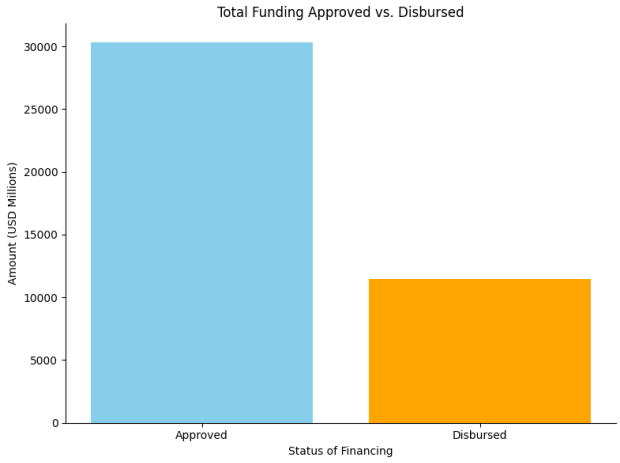

Figure 10: Total Funding Approved and Disbursed

Figure 11 separates approved and disbursed funding by objective. Adaptation projects focus on equipping systems to deal with the expected effects of climate change, while mitigation projects focus on reducing climate change, usually through a reduction of greenhouse gas emissions. Mitigation projects can be further specified as REDD+ if they are centered around reducing emissions from forest-related activities, such as deforestation and forest degradation. Projects with multiple objectives encompass both adaptation and mitigation. Figure 11 illustrates that nearly 55% of approved funding is targeted toward either general or REDD+ mitigation efforts. Only 23% of approved funding is targeted toward adaptation. Notably, most approved REDD+ funding has also been disbursed. Less than 50% of the funding approved for the other objectives has been disbursed.

The Climate Funds dataset lists 16 funding projects and programs in Malaysia, totaling $42.2

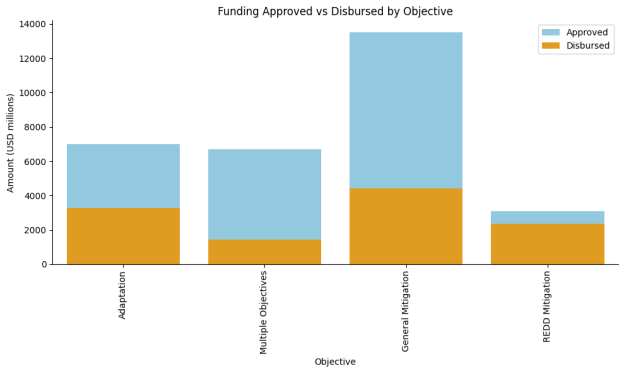

Figure 11: Funding Approved and Disbursed By Objective

million in approved funding and $22.9 million in disbursed funding. As seen in Figure 12, mitigation efforts are allocated the most funding, at $22.3 million. $20.5 million, or 92%, of this funding has been disbursed. Malaysia is at a high risk of experiencing flooding and other natural disasters exacerbated by climate change. However, only $1.5 million of the $10 million allocated toward adaptation efforts has been disbursed.

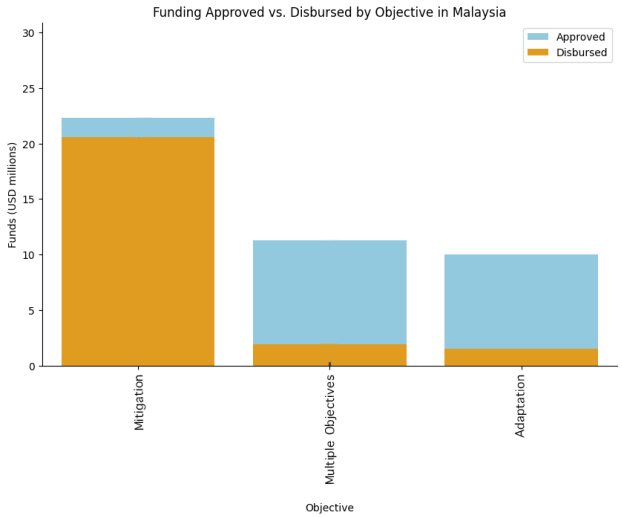

Figure 12: Funding Approved and Disbursed By Objective, Malaysia

5.2.2 Regressions

In this section, we employ regression analysis to examine the potential correlation between receiving funding from climate funds and three key variables: country income classification, region, and financing objective.

The correlation coefficients displayed in Table 4 are in reference to the low income category. Therefore, lower middle income countries generally receive more funding from climate funds than low

	(1) Total Climate Funds
Low income	0
	(.)
Lower middle income	0.595****
	(3.63e+11)
Upper middle income	-1.160****
	(-2.20e+11)
High income	-3.603****
	(-6.48e+11)
Not applicable	18.52****
	(7.13e+15)
_cons	4.453****
	(2.43e+15)
Number of observations	2297.00
Adjusted R-squared	0.02

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Table 4: Total Funding vs. Country Income Level

income countries, since the correlation coefficient is positive. This relationship was found to be statistically significant. However, as discussed in the Climate Funds Descriptives, this regression does not control for the number of countries within each income classification. Therefore, the coefficient of the income classification variable captures only the effect of income classification itself, not the effect of the number of countries within each classification. Upper middle income countries also generally receive more funding than low income countries, but to a lesser extent, given the smaller coefficient and lack of statistical significance. High income countries generally receive less funding than low income countries, but this result was also not found to be statistically significant. The adjusted R-squared indicates that none of the variation in funding can be explained by income classification alone.

	(1) Total Climate Funds
East Asia & Pacific	9.965****
	(4.76e+11)
Europe & Central Asia	0
	(.)
Latin America & Caribbean	-0.0200****
	(-2.81e+08)
Middle East & North Africa	19.31****
	(3.21e+11)
Not applicable	0
	(.)
South Asia	0.577****
	(3.18e+10)
Sub-Saharan Africa	-12.03****
	(-1.67e+11)
Western Asia	0
	(.)
_cons	3.660****
	(1.66e+12)
Number of observations	2297.00
Adjusted R-squared	0.02

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Table 5: Total funding and region

The correlation coefficients displayed in Table 2 are in reference to the 'Not applicable' category, which designates funding that is distributed across multiple regions. The regression of funding totals on region found no statistically significant results. Based on this analysis, there is insufficient evidence to conclude that there is a significant relationship between the region a country belongs to and the total amount of funding it receives. A general trend is that projects or programs in individual regions received less funding than projects or programs that span multiple regions. This observation aligns with the notion that a larger scope requires more funding. The disparity in funding is greatest in the Middle East and North Africa and least in South Asia. The adjusted R-squared indicates that 0.02% of the variation in funding can be explained by region alone.

	(1) Total Climate Funds
Adaptation	0
	(.)
Mitigation - General	4.303**
	(2.42)
Mitigation - REDD	2.987*
	(1.81)
Multiple foci	-2.148**
	(-2.43)
_cons	3.899****
	(13.24)
Number of observations	2056.00
Adjusted R-squared	0.04

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Table 6: Total funding and objective

The correlation coefficients displayed in Table 3 are in reference to projects and programs that have multiple objectives. Projects and programs focused on mitigation efforts generally receive more funding than those focused on multiple objectives or adaptation efforts. This result was found to be statistically significant. Funds or donors may prioritize funding projects and programs that primarily address mitigation efforts over those with a broader scope or those focused solely on adaptation. The adjusted R-squared indicates that merely 0.04% of the variation in funding can be explained by objective alone.

5.3 Private Financing

5.3.1 Descriptives

As seen in Figures 1 and 2, funding disproportionately goes to lower middle income countries (LMICs) and upper middle income countries (UMICs). While LMICs as a while receive the most total climate funding by far, when averaging across the number of countries in each group, UMICs recieve a comparable amount per country. On the other hand, very little funding is allocated to least developed countries (LDCs). This is likely because investors are less confident that LDCs can effectively use funding to enact real change.

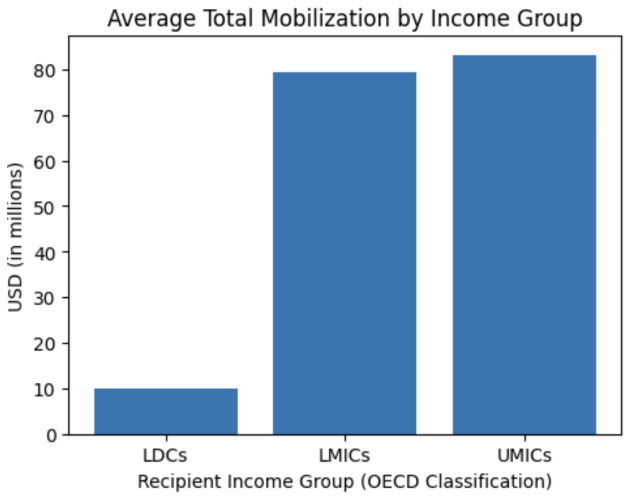

Figure 13: Average private financing by country income level group

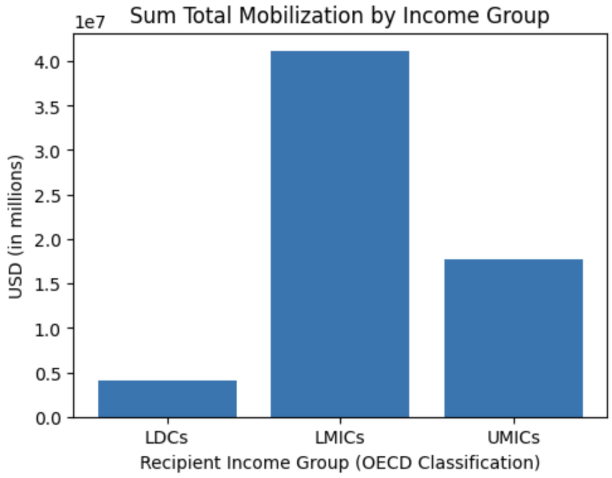

Figure 14: Average private financing by country income level group

5.3.2 Regressions

	(1) Private Funding by Income Total Private Funding
LDCs	0
	(.)
LMICs	-95.38****
	(-1.25e+12)
UMICs	-96.11****
	(-3.56e+11)
_cons	97.11****
	(1.85e+12)
Number of observations	7939.00
Adjusted R-squared	0.17

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Table 7: Effect of Income Classification on Private Funding (with controls and clustered SEs)

We obtained GDP per capita and population data from the International Monetary Fund's World Economic Outlook, then merged (on country) these data with our private funding data (OECD private funding data in addition to the private funding data from BloombergNEF that was obtained). We ran our linear regression, with our dependent variable as the amount of funding, our independent variable as income classification, and our control variables as the GDP per capita and population metrics. While controlling for GDP per capita is not particularly meaningful in this case since our independent variable is income classification, which depends on GDP per capita, but it is relevant for other metrics that we have also tested in order to isolate the effect of income from the effect of another metric. For instance, higher-income countries may receive less funding due to better existing infrastructure, or income level may also affect the level of pollution of a given country. On the other hand, we controlled for population because we've observed that countries with higher population have received more funding, which makes intuitive sense given the level of need that corresponds to the amount of infrastructure necessary for adapting to the needs of many households. Another method which we could have implemented is fixed effects, which could control for unobserved characteristics given the large number of omitted variables that our low R-squared value indicates. However, we believed that size and income are two of the largest and most important observable omitted variables. Here we observed a similar trend to what we observed from visualization and from previous trends for public funding and climate funds funding. LMICs and UMICs receive less funding than LDCs. One potential interpretation could be that higher-income countries are less in need of funding, or that for private funding specifically, the risk premium for investing in these countries is lower than for investing in a low-income developing country. Hence investors might prefer areas with higher returns.

	(1) Total Private Funding
Credit lines	0
	(.)
Direct investment in companies and SPVs	29.86*
	(1.80)
Guarantees	31.87**
	(2.03)
Shares in CIVs	13.24
	(0.72)
Simple co-financing	-30.77****
	(-3.57)
Syndicated loans	8.275
	(0.54)
_cons	-29.50*
	(-1.88)
Number of observations	7939.00
Adjusted R-squared	0.22

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Table 8: Effect of Sector on Private Funding (with controls and clustered SEs)

With credit lines as a reference point, we observe that direct investment and guarantees are the top sources of private funding. The coefficient we obtained for direct investment is 29.86, and for guarantees 31.87. While guarantees' representation is in line with the prevalence of its usage among private financing mechanisms, we find it surprising to see that direct investment also occupies a large share of funding because literature review has previously informed us about the relative dearth of equity financing relative to credit/debt financing, including loans. This might be related to the proportion of SPV (special-purpose vehicles) which allows liquidity to take on the form of certain financial structures.

	(1) Funding Totals on Sector Total Funding
Agriculture, Forestry, Fishing	31.46
	(1.61)
Banking and Business	82.16****
	(3.63)
Economic and Social Infrastructure	88.93****
	(3.88)
Education	26.27
	(1.36)
Energy	78.94***
	(3.12)
Government and Civil Society	36.52*
	(1.85)
Health	40.50**
	(2.03)
Industry and Mining	53.72**
	(2.12)
Water	0
	(.)
_cons	-88.91****
	(-3.88)
Number of observations	7332.00
Adjusted R-squared	0.18

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Table 9: Effect of Financing Mechanism on Private Funding (with controls and clustered SEs)

While our original dataset originally came with a more detailed breakdown of the various different sectors, we realize that it would be more meaningful if we aggregate data from the same broad sector. For example, we combined Basic Health and Public Health as one category of health, and Secondary Education and Primary Education as one category of Education. Our regression table assumes that such post-processing does not alter the general trend of the distribution of private funding across sectors. In particular, we realize that banking and business, and economic and social infrastructure represent a large majority of private mobilized funding. We believe that this is true because a lot of projects are dedicated toward improving the economic and financial structure of a given economy in order to facilitate the process of financing, so that while Health and Education may be important target areas for these financing, they may be categorized under Banking and Business because they address the intermediate link crucial to the act of financing itself.

5.4 Total Financing

5.4.1 Descriptives

In order to develop a more profound analysis of trends in global climate finance flows, our team used a merged dataset containing information from both the OECD Mobilization and OECD Public Finance data sources to generate a series of summary statistics and visuals revealing disparities in total climate funding (from both public and private sources) across 166 recipients in 2021. Our observations are split on variables such as recipient region, OECD income classification, source of funding, and sector distribution of consumed funding. Data on China was excluded from certain parts of these analyses to minimize extraneous magnification of funding variations.

Total Funding by Recipient Region Figure 1 displays the results of a descriptive analysis of total climate funding by recipient region in 2021.

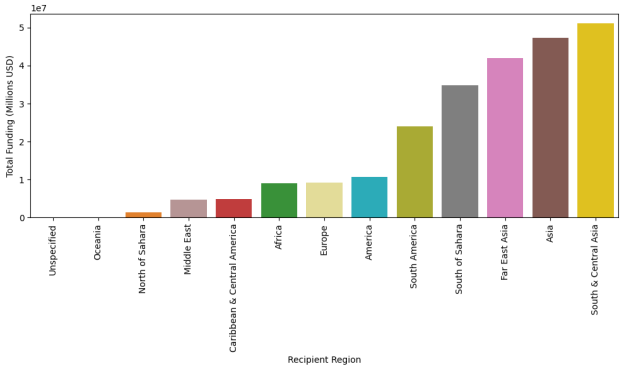

Figure 15: Total funding by recipient region in 2021 (Millions USD), excluding China

The bar chart indicates that countries in South & Central Asia received the most funding, with approximately $51.08M USD in total, while Oceania received the least funding, with approximately $0.05M USD in total. Malaysia is classified within the Far East Asia category, which received the third highest amount of funding. As the bar chart uses a logarithmic scale, differences in the heights of bars represent exponential differences in funding.

Total Funding by Income Category Figure 2 illustrates the results of a descriptive analysis of total climate funding by income category, as established by the OECD.
Funding is heavily concentrated in Lower Middle Income Countries (LMICs), a category that includes India, Indonesia, and Sri Lanka, among others. LMICs received approximately $139.76M, while Upper Middle Income Countries – including Malaysia – received approximately $66.89M USD and Least Developed Countries received approximately $32.21M USD. These findings align with the trends displayed in Fig. 1 – out of the 38 countries and regions that were classified as LMICs in 2021 by the OECD, nearly 70% are in Asia or in Sub-Saharan Africa, which are the regions that received the highest amounts of total climate funding.

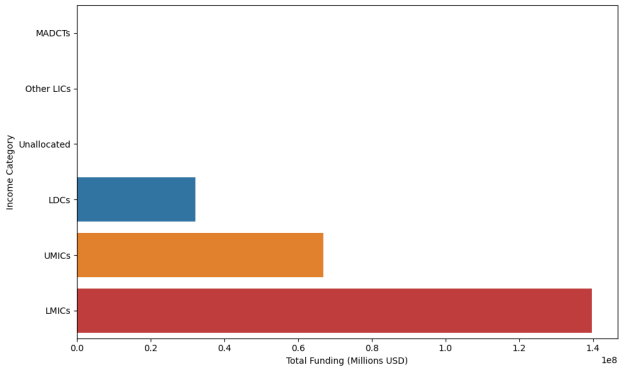

Figure 16: Total funding by income category in 2021 (Millions USD), excluding China

Sector Distribution of Funding After identifying the top 10 and bottom 10 countries in the merged dataset by total funding, we proceeded to conduct an analysis of the sector distribution of the funding mobilized by the aforementioned countries.

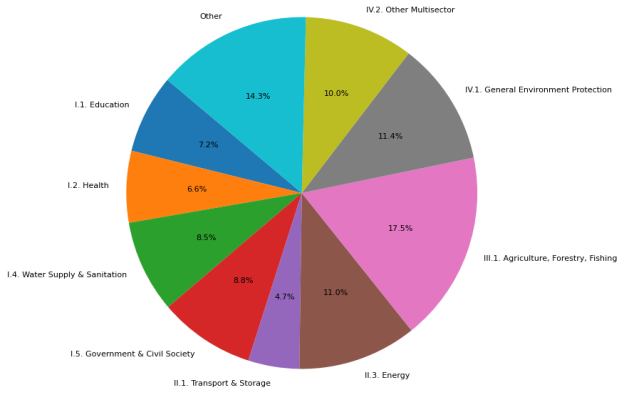

Figure 17: Sector distribution of funding for top 10 countries by total funding (sectors > 4% and Other), including China

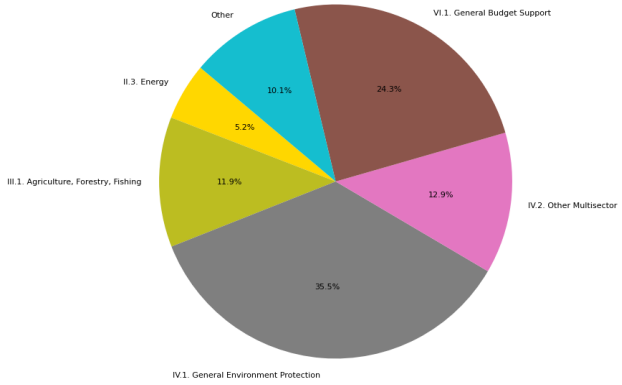

Figure 18: Sector distribution of funding for bottom 10 countries by total funding (sectors > 4% and Other), including China

For the top 10 countries by total funding, the largest percentage of funding was mobilized for projects in the Agriculture, Forestry, Fishing category, while the most common funding destination for the bottom 10 countries was General Environment Protection. For both the top 10 and bottom 10 countries, the top 5 sectors that received the most funding included Other, Other Multisector, General Environment Protection, and Agriculture, Forestry, Fishing. Energy is also a notable sector in both pie charts. Sector distribution for the top 10 countries is notably more diverse and less generalized than for the bottom 10 countries.

Provider Distribution of Funding Figures 5 and 6 demonstrate that the distribution of funding providers for the top 10 and bottom 10 countries by total funding is highly similar.

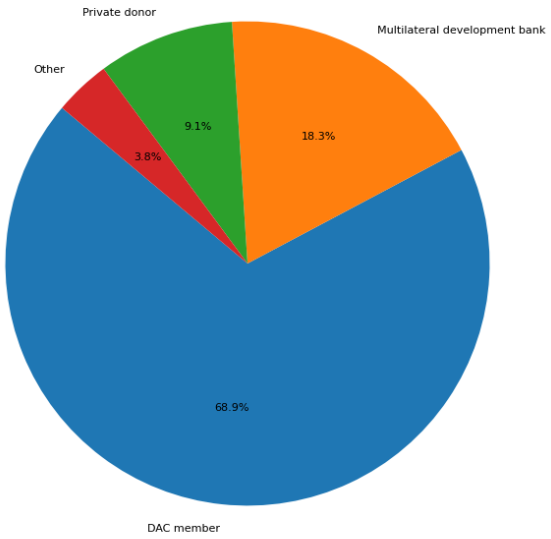

Figure 19: Provider distribution of funding for top 10 countries by total funding (providers > 4% and Other), including China

More than 50% of the funding received by each data group was provided by Development Assistance Committee (DAC) members, while MDBs were the second most common funding distributor in both analyses. One notable difference is that private donors provided a higher proportion of funding to the top 10 countries than to the bottom 10 countries, by a difference of 2.2 percentage points.

Global Heatmap Figure 9 displays the total climate financing, both public and private combined, for each country on a global map. The countries with highest funding are India, Brazil, Turkey, and funding is generally concentrated in Asia, Central and South America, Africa, and East Europe. Although funding is distributed across many regions, there is a large discrepancy between the top countries and other countries receiving some funding. India's funding, for example, is several orders of magnitude larger than most countries in Africa.

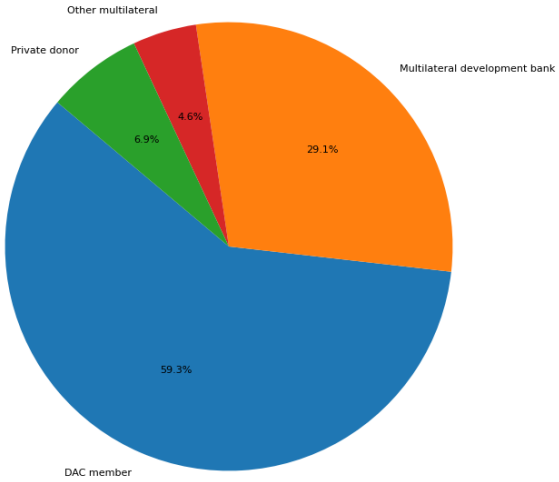

Figure 20: Provider distribution of funding for top 10 countries by total funding (providers > 4% and Other), including China

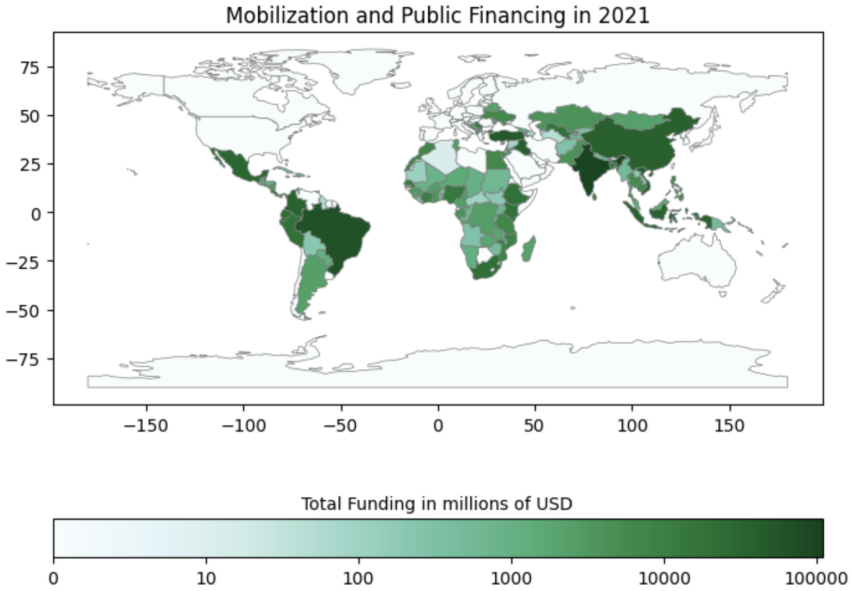

Figure 21: Global heatmap of total climate financing

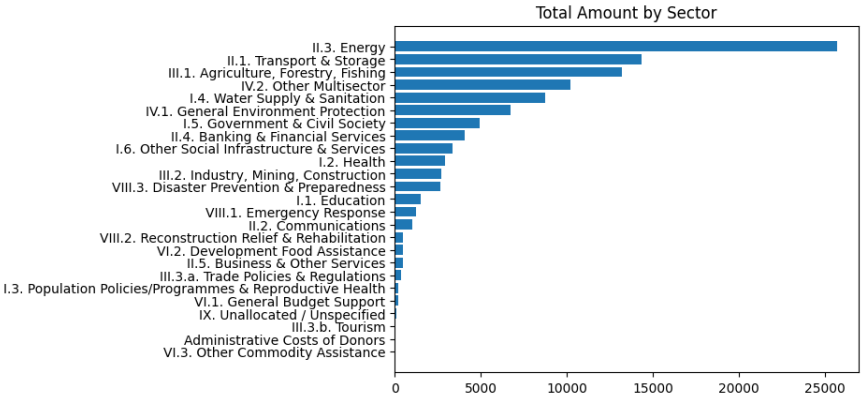

Figure 23: World Total Financing Amount by Sector

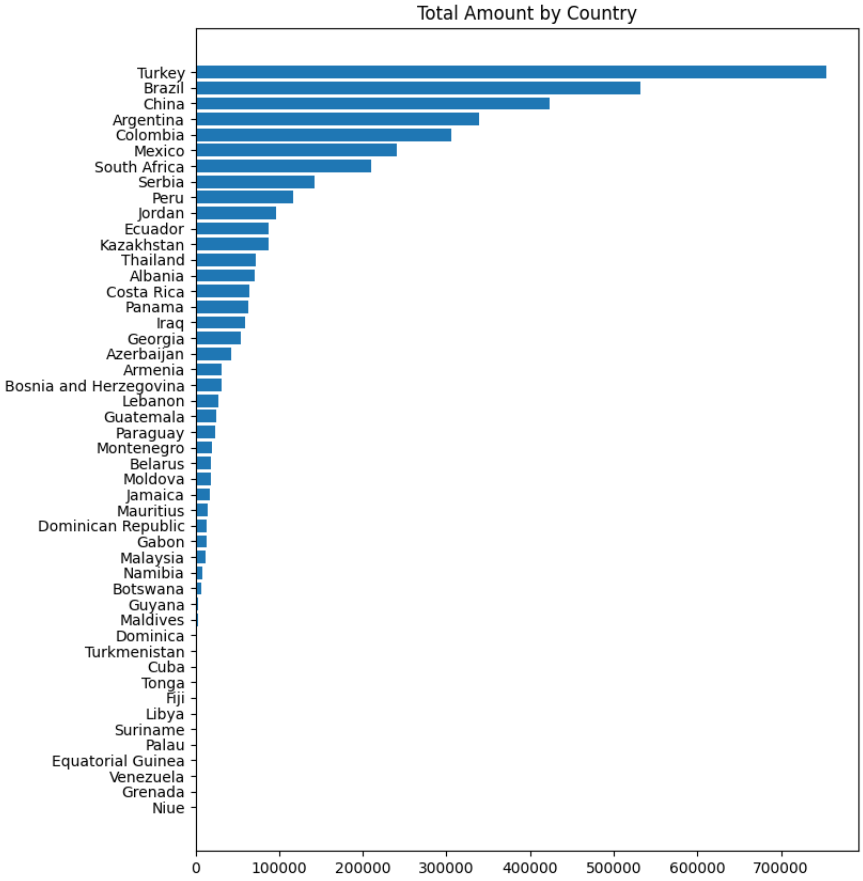

Figure 22: World Total Financing Amount by Country

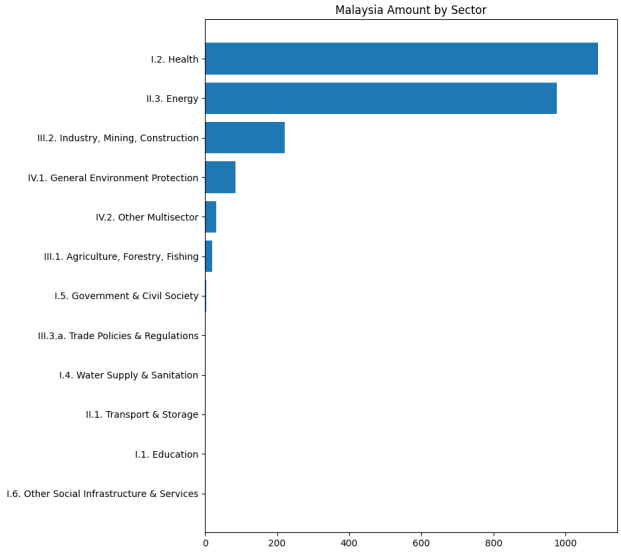

Figure 24: Malaysia Total Financing Amount by Sector

6 Malaysia Adaptation Financing Results

6.1 Malaysia's Sea Infrastructure Needs

While global sea level rise (SLR) is predicted to be around 1.7-3.1mm/year, the regional sea level rise for Malaysia is predicted to be higher, given that recent trends have shown acceleration. The observed rate for Malaysian coast from GIS satellite data is between 2.7-7.0mm/year, with 0.25-0.5mm/year for Peninsular Malaysia, 0.69-1.6mm/year for Sabah, and 0.43-0.64mm/year for Sarawak, and maximum value occuring in low-lying areas. (Awang and Hamid (2013)) According to the National Coastal Erosion Study conducted in 2015, 15% of the 8840km of Malaysia's coastline is under the critical category. Most notably, Sarawak occupies 163.4km of the 431.3km in total, and Sabah follows with 82.1km. (Ahmad Hadi Mohamed Rashidi (2021)) In terms of adaptation measures and options that have been explored, hard structures such as seawalls and rock revetment are considered the cheapest, most effective, and most population implementations, yet deforestation of mangroves and the expansion of beach widths are primary consequences. Hence more porous submerged breakwater structures and geo-textile tubes have also been innovated. On the other hand, soft-engineering and a more ecologically based approach may be more environment-friendly while more costly and less effective in the short-run, though long-run potential is looked upon favorably. These include beach nourishment and mangrove rehabilitation especially due to mangroves' resilience to heavy waves and tidal activities. In modelling potential costs, we could divide these infrastructures into useful sub-categories in order to infer the aggregate.

6.2 Predicted Financing Needs

There are many factors contributing to sea-level rise such as ocean thermal expansion, glacier changes, and the melting of the Greenland and Antarctic ice caps. However, the speed and magnitude of these factors on the impact of climate change and climate-related disasters is uncertain. The probability distribution of how extreme the impacts could be include long tails to extreme catastrophes. There are many economic models that attempt to quantify the cost of financial needs of adapting to changes in the climate. Each of these models operate under different assumptions about both how different factors affect climate outcomes and how much impact they have. Under optimistic models, flood management costs are projected to be 0.3-5% of the GDP in 2100 under constant damage protection, while other models predict up to 9.3% of 2100 GDP (Hinkel et al. (2014)).

Cost-benefit analysis can be used to more precisely estimate the effect of building sea infrastructure. For example, Cooper et al. (2016) compares the damage of Hurricane Sandy to the cost of berm construction to quantify its impact. The costs they consider include the financial needs of things such as land acquisition, construction, and maintenance. The benefits considered include the value of infrastructure damaged in the hurricane that would have been avoided with the berm, economic revitalization, and general environmental and social value. The total estimated costs are $384.2

million, while the estimated benefits are $76.06 million per year. This leads to an estimated annual net value (benefit - cost) of $65.40 million. The paper considers two future discount rates, and with the higher rate of 7% considered, the break even point would be in 2029, 17 years after the hurricane.

7 Conclusion

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