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Abstract

Efforts to address climate change have generally been focused on deploying mitigation technologies. However, it is adaptation technologies (and climate risk transfer) that will have to gain an increasing share of an investment pool dedicated to climate if human systems are to stay resilient to climate forces. Just like mitigation projects, adaptation projects have a strong public goods aspect, wherein public returns exceed private returns, and thus call for the state's involvement. We argue that sovereign climate funds (SCFs) - new types of sovereign wealth funds with a climate investment mandate - can be critical purpose-built conduits especially for undertaking the needed decades-long programs of allocating resources to adaptation projects, without hindrance from political biases or "short-termism". They can also function as "cushions" against potential future climate funding shortfalls and dispense payouts when climate disasters strike. We discuss the various climate-related adaptation investments that SCFs would be particularly well-suited to undertake.

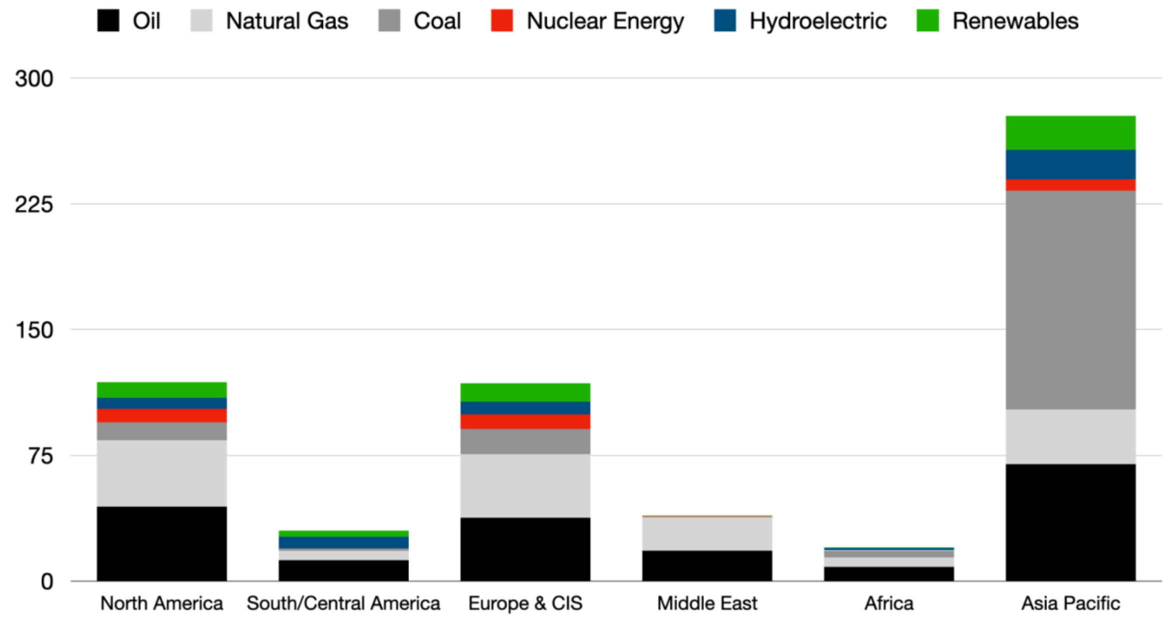
Mitigation Vs. Adaptation

Mankind's three-decade long struggle to address climate change has generally been focused on deploying mitigation technologies. The best-known of the mitigation technologies is, of course, the "alternative energy" complex. Other mitigation technologies - based on the same premise that relates atmospheric carbon to climate change - include energy efficiency technologies, electrified transport and heat, and power grids, as well as carbon capture and carbon sequestration. Indeed, all technologies that can produce carbon "offsets" are, by and large, mitigation technologies.

Ideally, implementation of mitigation technologies could slow down climate change by reducing carbon emissions into the atmosphere. However, it is becoming more evident that the problem of climate change will not be resolved using the current generation of mitigation technologies. Despite large investments into the sector, non-fossil fuel energy supplies still represent only 18.2% of the global total primary energy consumption and are growing too slowly to make a big difference.[1] Moreover, the rate of adoption of renewable energies remains somewhat beholden to the price of oil, and public incentives and subsidies. For the most part, carbon capture and sequestration are prohibitively expensive, whereas long term electricity storage (required to balance variable-output renewables) is both expensive and inefficient. Meanwhile, stable and scalable nuclear fusion - the ultimate source of clean, cheap, abundant, and constant energy - remains, for now, out of humanity's reach.

[1] Energy Institute, The 2023 Statistical Review of World Energy. https://www.energyinst.org/statistical-review

Exhibit 1: Primary Energy Consumption by Fuel Type, 2022, Exajoules



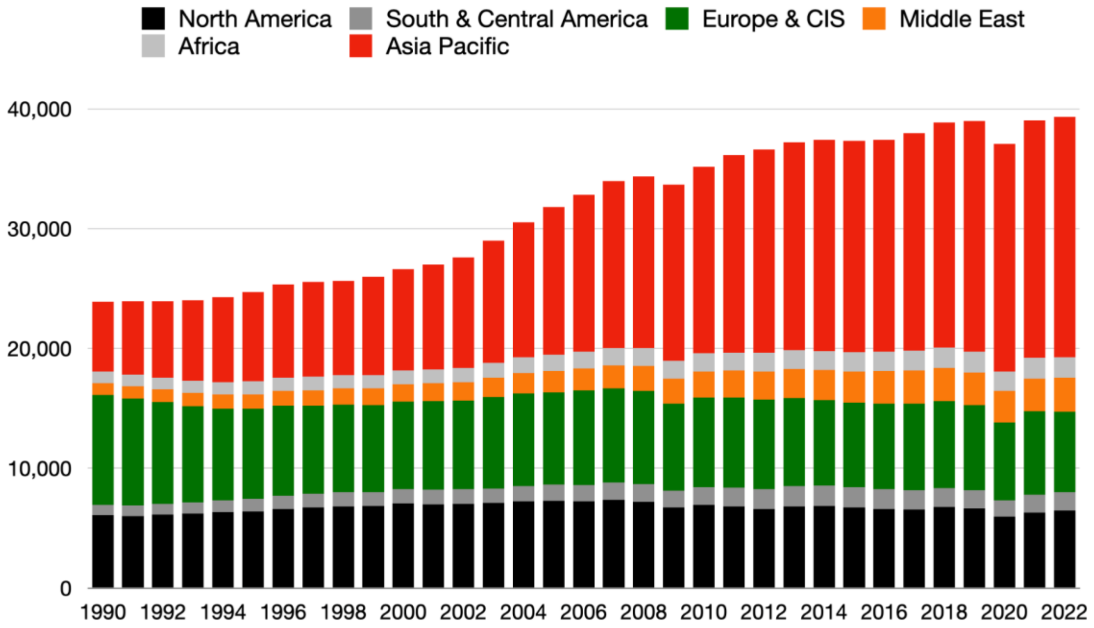
Source: Energy Institute Statistical Review, Macquarie Group, SMU/SKBI, Turning Point Macro

Debates surrounding the "net zero" path bear upon how much effort is still required. To limit the global average temperature increase to 1.5°C relative to pre-industrial norms, 195 nations signed the 2015 Paris Climate Accords, which target an average 45% emissions reduction by 2030, and zero new carbon emissions (hence, "net zero") by 2050. Yet instead, annual global carbon emission from fossil fuels and industry rose from 36.16 gigatonnes (Gt) in 2015 to 38.52Gt in 2022, a 6.5% increase[2]. The 2023 World Energy Transitions Outlook, published by International Renewable Energy Agency (IRENA), suggests that if the announcements made during the Conference of the Parties (COP) are considered, global emissions will decrease to only 34Gt level by 2030, vs the 23Gt required to reach the net zero target by 2050.[3] IRENA's report goes further, outlining what it calls a Planned Energy Scenario (based on governments' energy plans and other planned targets and policies), and indicating that if it comes to pass, the net zero "ceiling" will be breached in 2050, by the extra 16Gt CO_2.

[2] European Commission, Emissions Database for Global Atmospheric Research, 2023 Report. https://edgar.jrc.ec.europa.eu/report_2023. By comparison, total global CO2 emissions (inclusive of land use) rose from 50.13 Gt in 2015 to 53.77 Gt in 2022, a 7.3% increase.

[3] International Renewable Energy Agency (IRENA), World Energy Transitions Outlook 2023: 1.5ºC Pathway, https://www.irena.org/Publications/2023/Jun/World-Energy-Transitions-Outlook-2023.

Exhibit 2: Carbon Dioxide Equivalent Emissions from Energy, Process Emissions, Methane, and Flaring, Million Tonnes Equivalent



Source: Energy Institute Statistical Review, Macquarie Group, SMU/SKBI, Turning Point Macro

Nowhere are the challenges facing climate mitigation as evident as in the realm of investments. While the estimates of the size of private and public capital commitments required to reach the net zero vary, the 2023 IRENA report suggests a USD 150 trillion need, averaging over USD 5 trillion in annual terms. This dovetails with the Glasgow Financial Alliance for Net Zero (GFANZ) pledge to deliver USD 100 trillion of finance for net zero projects from 450 firms across 45 countries (collectively commanding USD130 trillion of private capital).[4] Unfortunately, although global investment in energy transition technologies reached a record USD 1.3 trillion in 2022 (as per IRENA estimates) - and then another record USD 1.77 trillion in 2023 (as per BloombergNEF Energy Transition Investment Trends 2024 report)[5], this falls far short of the average annual need. Further, while the GFANZ COP26 pledge was hailed at the time as a "watershed" moment,[6] bankers at the 2023 COP have attached many more conditions to their commitments underlying the headline figure. "You need availability of projects; there may be USD 130 trillion or more of capital, but it is return-seeking capital, so you need bankable investments that actually provide appropriate risk and return," said Ramaswamy Variankaval, JPMorgan's global head of corporate advisory and

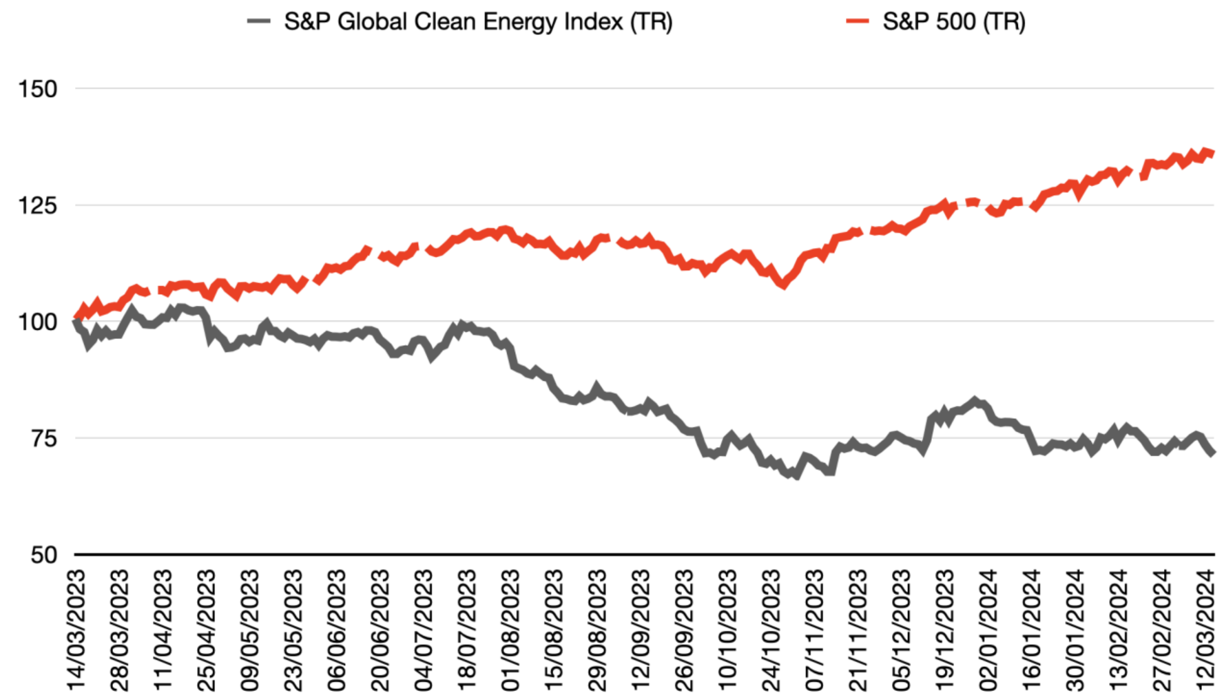
[4] GFANZ, Amount of finance committed to achieving 1.5°C now at scale needed to deliver the transition, 3 November 2021, https://www.gfanzero.com/press/amount-of-finance-committed-to-achieving-1-5c-now-at-scale-needed-to-deliver-the-transition/.

[5] BloombergNEF, Energy Transition Investment Trends 2024, 30 January 2024, https://assets.bbhub.io/professional/sites/24/Energy-Transition-Investment-Trends-2024.pdf

[6] Howard Davies, Cop26 could be a watershed in greening the financial sector, The Guardian, 3 December 2021, https://www.theguardian.com/business/2021/dec/03/cop26-could-be-a-watershed-in-greening-the-financial-sector.

sustainable solutions.[7] This "reality check" follows a period of financial losses for sustainability investors. The S&P Global Clean Energy Index (launched in February 2007), delivered only 4.40% in total return to investors for the past 10 years on an annualized basis, vs 12.82% for the benchmark S&P 500. These losses were particularly pronounced in the last 12 months, with the (total return) Clean Energy Index falling -25.72%, while S&P 500 (total return index) climbing 34.32% (priced as of March 19, 2024).[8]

Exhibit 3: S&P Global Clean Energy Index vs S&P 500 Total Return Index Performance



Source: S&P Global, Macquarie Group, SMU/SKBI, Turning Point Macro

There is something else to consider: recent science reports suggest that the goal of stabilizing climate conditions has already become too remote for the mitigation technologies to achieve, even with faster adoption. To wit, the 2020 UK's Royal Society report Climate Change Evidence and Causes, said that even "if emissions of carbon dioxide stopped altogether, it would take many thousands of years for atmospheric carbon dioxide to return to pre-industrial levels"[9]. That's due to the very slow absorption of excess atmospheric carbon into the deep ocean and its ultimate burial in ocean sediments - the organic way by which the Earth would "heal". As such, it is quite probable that "the current CO2-induced warming of Earth is therefore essentially irreversible on a human timescale" and Earth's surface temperatures would stay elevated, implying a long-term reality of a warmer planet. If the Royal Society's conclusion is valid,

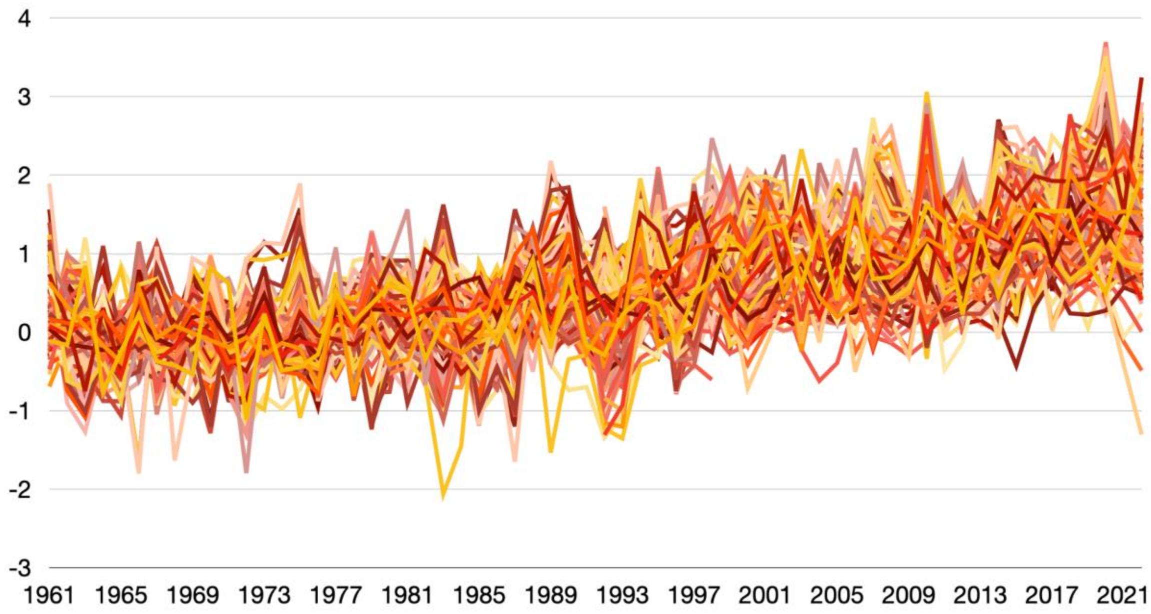
[7] Alastair Marsh, Billionaire Bridgewater founder Ray Dalio says private capital can only realistically finance climate solutions if the returns make sense, Fortune, 7 December 2023, https://fortune.com/2023/12/07/bridgewater-ray-dalio-private-capital-climate-solutions-returns

[8] S&P Dow Jones Indices, S&P Global Clean Energy Index, proceed as of 19 March 2024, https://www.spglobal.com/spdji/en/indices/esg/sp-global-clean-energy-index/#overview.

[9] The Royal Society, Climate Change: Evidence and Causes, Update 2020, https://royalsociety.org/-/media/education/teacher-consultant-resources/climate-change-evidence-causes.pdf

mankind's attempts to significantly curtail the more adverse effects of climate change via the deployment of mitigation technologies is bound to disappoint. This is not to say, of course, that mitigation technologies won't enhance human welfare. Without them, the sheer speed of current global warming - more than ten times that at the end of an "ice age"[10] - may bring humanity to the brink of extinction. **Most would agree that if such risk could be avoided, it's worth the effort.**

Exhibit 4: Temperature change with respect to a baseline climatology (corresponding to the period 1951-1980) across 224 countries and territories, 1961-2022



Source: IMF, SMU/SKBI, Turning Point Macro, Macquarie Group

Enter Adaptation Technologies

What are climate adaptation technologies? Unlike mitigation technologies, which seek to reduce or reverse the trend in climate change by addressing the volume of atmospheric carbon, adaptation technologies (or adaptation modalities) refer to technologies and projects that seek to avert losses in welfare by shielding societal systems from the effects of changing climate, or by helping human activity align with their environments. One of the oldest examples of adaptation technologies (dating to between 4,000BC and 1,300BC) are Middle Eastern wind *catchers*, which use passive air cooling to lower indoor temperature by up to 10°C.[11] In the other part of the world, the Dutch began building wind *mills* around the

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10 NASA, How Do We Know Climate Change is Real, Accessed on 20 March 2024, https://climate.nasa.gov/evidence

11 Shervin Abdolhamidi, An ancient engineering feat that harnessed the wind, BBC Travel, 27 September 2018, https://www.bbc.com/travel/article/20180926-an-ancient-engineering-feat-that-harnessed-the-wind

1,200 AD, to act as pumps to prevent flooding. Examples of the more modern adaptation technologies include satellite imaging and weather monitoring systems to provide early warnings of extreme weather events, smart irrigation systems, precision farming, drones, and remote sensing to help farmers adapt to changing weather patterns, desalination plants and water recycling systems to help communities adapt to changes in water availability and quality, green roofs and urban gardens to mitigate urban heat islands, cyclone-resistant building designs, etc. **Adaptation can also come in the form of climate risk-management products, such as climate risk pooling, insurance, and issuance of climate catastrophe bonds.**

Even some mitigation technologies can have adaptation features. For example, replacing fossil-fuel based public inner-city transport with electrified public inner city transport, while primarily intended to reduce carbon emissions (a mitigation effort), can also improve air quality (an issue typically viewed as local public good) and produce health co-benefits, thereby alleviating potential health risks, deaths and budgetary losses stemming from climate change. The 2022 Lancet Commission Report on pollution and health indicates that air pollution was responsible for 9 million premature annual deaths worldwide in 2015-2019[12], while the European Environment Agency estimates that poor air quality led to at least 238,000 premature deaths in the EU in 2020 alone.[13] The 2023 WHO report goes on to suggest that "reducing emissions of greenhouse gasses through better transport, food and energy use choices can result in very large gains for health, particularly through reduced air pollution."[14] As another example, mitigation strategies that both reduce natin's carbon emissions *and* improve reliability and climate resilience of its energy supplies (e.g. by rendering nation's energy systems more resilient to supply-chain disruptions) also have adaptation aspects (by making every local energy consumer an ultimate beneficiary).

A critical point about adaptation technologies is that they are agnostic to whether climate change is man-made or not. They simply focus on addressing the pernicious effects of climate change, whatever its origin, by improving resilience. **What will mark the 21st century is that adaptation technologies will need to be built into the planning, design, financing, and implementation of new development projects and communities - perhaps every new habitat**. In other words, adaptation will become "mainstreamed."

We've seen how the lack of adaptation - or its inadequate deployment - can be both costly and deadly. As an example, according to the European Environment Agency, the total economic losses from weather- and climate-related events across EU member states reached over EUR 650 billion (in 2022 EUR) between 1980 and 2022.[15] The losses grew by 41% from 2009 to 2022 using a 30-year average, and less than 20% of the losses were insured. In the meantime, the World Economic Forum's Global Risk Report

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12 Richard Fuller, Philip J Landrigan, Kalpana Balakrishnan, Glynda Bathan, Stephan Bose-O'Reilly, Michael Brauer, et al., Pollution and health: a progress update, The Lancet, Planetary Health, 17 May 2022, https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(22)00090-0/fulltext

13 European Environment Agency, Premature deaths due to air pollution continue to fall in the EU, more efforts needed to deliver a toxic-free environment, 24 November 2022, https://www.eea.europa.eu/en/newsroom/news/premature-deaths-due-air-pollution

14 World Health Organisation (WHO), Climate Change, 12 October 2023, https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

15 European Environment Agency, Economic losses from weather- and climate-related extremes in Europe,, 6 October 2023, https://www.eea.europa.eu/en/analysis/indicators/economic-losses-from-climate-related?activeAccordion=

2024 suggests that in Australia, around 521,000 homes will become uninsurable by 2030, due to the risks of extreme weather.[16]

Consequences of the 2021 heavy rains in Nepal offer another stark illustration of the cascading (or "risk-multiplying") effects of climate-related events. According to the 2022 World Bank report, "the first onslaught began in June, when monsoons arrived two weeks earlier than usual and dumped more than 300 mm of rainfall on the central and western parts of the country in one week. In the two months that followed, heavy rains upstream triggered a massive erosion of glacial deposits, overtopping of a moraine lake, and the temporary damming and sudden release of water at the elevation of over 3,500 meters above sea level. This sent water and debris tumbling 40 km along the Melamchi River to the market town of Melamchi. The debris flow inundated parts of the community, ripping bridges from their moorings and sending them into the river, where they acted as dams that trapped rubble from the landslide upstream. The headworks of the $800 million project at Melamchi to deliver water to the capital Kathmandu was buried under 10-meter layer of rocks and mud. The same weather system impacted other mountain districts of Gorkha, Manang and Mustang. Numerous settlements were wiped out and thousands of hectares of agricultural land were damaged. The second disaster came in October, two months after a typical Nepal monsoon season would have ended. Heavy rains moved across western Nepal, killing residents and damaging roads, bridges, hydropower stations and other infrastructure."[17] **The Nepal example might be extreme, but it illustrates close links between the economy and nature.** According to a 2020 joint World Economic Forum and PWC report, more than half of the world's total GDP is "moderately or highly dependent on nature and its services and is therefore exposed to nature loss."[18] Furthermore, the Swiss Re Institute 2021 stress tests indicate that the global economy could lose over 18% GDP by 2050, if temperatures rise by 3.2°C vs pre-industrial levels, instead of the 1.5°C Paris-specified limit.[19]

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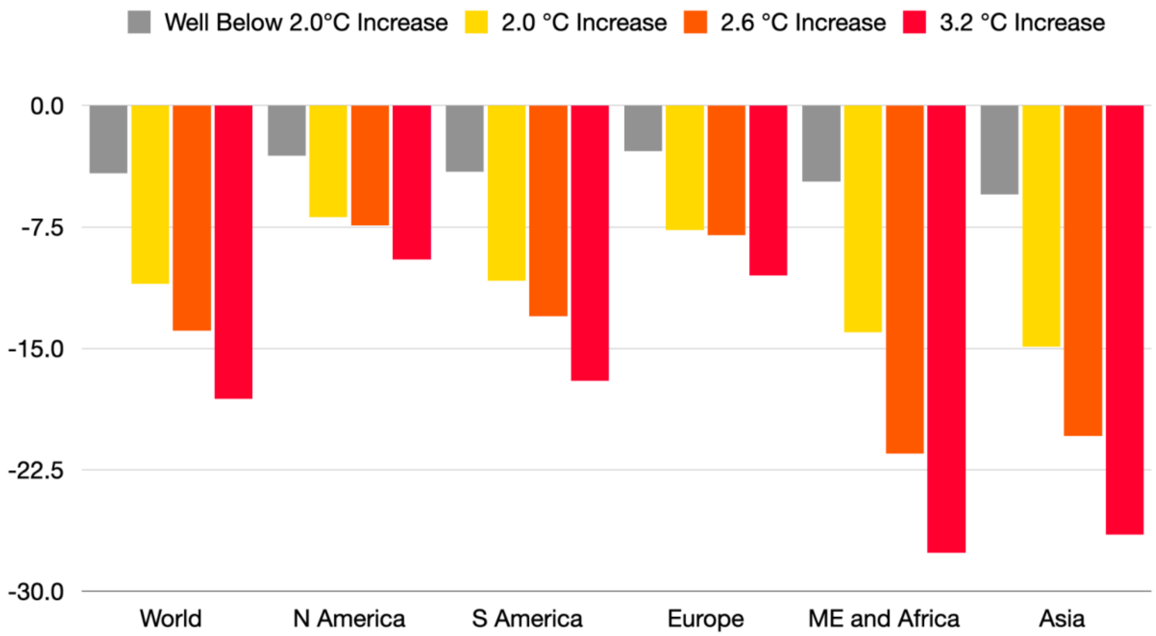
[16] World Economic Forum, The Global Risks Report 2024, https://www.weforum.org/publications/global-risks-report-2024/

[17] The World Bank, In Nepal, 2 Major Climate Disasters in a Single Year Highlight the Need to Build Resilience, 31 March 2022, https://www.worldbank.org/en/news/feature/2022/03/28/in-nepal-2-major-climate-disasters-in-a-single-year-highlight-the-need-to-build-resilience

[18] World Economic Forum, Nature Risk Rising, January 2020, https://www3.weforum.org/docs/WEF_New_Nature_Economy_Report_2020.pdf

[19] SwissRe Institute, The economics of climate change: no action not an option, April 2021, https://www.swissre.com/dam/jcr:e73ee7c3-7f83-4c17-a2b8-8ef23a8d3312/swiss-re-institute-expertise-publication-economics-of-climate-change.pdf

Exhibit 5. Simulated Economic Losses from Rising Temperatures, % GDP



Source: SwissRe Institute, Macquarie Group, SMU/SKBI, Turning Point Macro

An argument, thus, could - and should - be made for the development and deployment of the adaptation technologies alongside mitigation technologies. Good adaptation technologies are those that protect societal systems. *Better* adaptation technologies help align society with new climate norms, and *protect existing mitigation projects.* **And, of course, the functioning of adaptation systems themselves must be resistant to climate change.** For example, a drip irrigation system that helps adapt to aridification of farmland must also withstand floods, heat, occasional burnouts, etc., and have redundancies embedded to avoid system failure. Adaptation technologies deployed in coastal areas, for example, must be viable for a range of sea-level change up to several feet over decades, but also for occasional hurricanes, fires, sediment deposition and erosion, and intrusion of saltwater into groundwater. Insurance systems will have to continuously be updated to reflect changing perils. If adaptation can be implemented using nature-based solutions, such as natural hazard protection through restoration of mangroves and corals, even better.

Climate Mitigation Is An International Public Good

Historically, a new technology would supplant an old technology whenever the expected private benefit of adopting the technology exceeds the private costs of adopting it. Of course, if a new technology had positive "externalities" - thereby deeming it a public good - it would be up to the state to offer incentives to inventors, innovators, and investors to deploy such technology on a scale that ensured that the private cost did not exceed the public benefit. Alternatively, if an innovation was particularly beneficial to those with low/er incomes, the state could justify its intervention on the basis of redistribution.

All climate mitigation technologies are clearly public goods. In fact, they are *international* public goods, since the benefit of offsetting carbon in the atmosphere accrues to everyone on Earth.

Indeed, almost everyone on Earth is a "free-rider" to the benefits of mitigation, which generates what is known as a "positive externality". That has justified both multilateral and national interventions via subsidies, incentives, guarantees, as well as the efforts to put a "price" on carbon as an allocative mechanism.

A good example of a policy initiative supporting mitigation is the carbon market, where emitters, which need to exceed their carbon "budget", can purchase carbon "credits" via mandatory compliance schemes, known as "cap-and-trade" or Emission Trading Systems (ETS). ETS are regulated by national, regional, and international carbon reduction regimes. In 2023, the global ETS market reached USD 948.75 billion, a 2% year-over-year increase, according to February 2024 London Stock Exchange Group report - though the prices of national carbon credits vary widely[20]. Reuters calculates that they range from EUR 60 -100 per ton in the EU, to USD 15-39 per ton in the US, to around USD 11 per ton in China[21]. **In parallel to ETS, there exists a smaller yet growing "voluntary" carbon market (VCM).** The VCM is where corporations, non-profit organizations and individuals can purchase carbon "offsets" to voluntarily lower their carbon footprint and thus overall emissions. Despite several high profile scandals, demand for the traded "offsets" remains strong. Boston Consulting Group expects VCM to expand from US 2 billion in 2021 to between US 10 billion and US 40 billion in 2030.[22]

Other well-known policy initiatives underscoring mitigation are tax-based and subsidy-based incentive systems. As an example, the 2021 US Bipartisan Infrastructure Deal (Infrastructure Investment and Jobs Act) calls for USD 65 billion investment in clean energy transmission and the electric grid, USD 21 billion investment in cleaning up Superfund (locations polluted with hazardous materials) and brownfield sites, reclaiming abandoned mine land, and capping orphaned oil and gas wells, USD 7.5 billion investment in the first-ever US network of EV chargers, and USD 5 billion in funding for public transit agencies to adopt low- and no-emissions buses.[23] In another example, the 2022 US CHIPS and Science Act includes an USD 800 million allocation for "fission for the future," targeting establishment of a federal assistance program to support the research, development, and demonstration of advanced nuclear reactors, with an emphasis on projects in fossil fuel communities.[24] Finally, the 2022 US Inflation Reduction Act aims to reduce US carbon emissions by around 40% by 2030, by allocating nearly $370 billion to clean energy and climate priorities though the combination of clean-energy tax credits, sustainable fuel incentives, residential energy and efficiency tax credits, clean vehicle tax credits, low-carbon construction material incentives, and clean energy financing, among other things.[25]

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[20] Reuters, Global carbon markets value hit record $949 bln last year - LSEG, 12 February 2024, https://www.reuters.com/markets/commodities/global-carbon-markets-value-hit-record-949-bln-last-year-lseg-2024-02-12/

[21] Ibid.

[22] Anders Porsborg-Smith, Jesper Nielsen, Bayo Owolabi, and Carl Clayton, The Voluntary Carbon Market Is Thriving, Boston Consulting Group, 19 January 2023, https://www.bcg.com/publications/2023/why-the-voluntary-carbon-market-is-thriving

[23] White House, The Bipartisan Infrastructure Deal Boosts Clean Energy Jobs, Strengthens Resilience, and Advances Environmental Justice, 8 November 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/11/08/fact-sheet-the-bipartisan-infrastructure-deal-boosts-clean-energy-jobs-strengthens-resilience-and-advances-environmental-justice/

[24] Bipartisan Policy Center, CHIPS and Science Act Summary: Energy, Climate, and Science Provisions, 14 November 2022, https://bipartisanpolicy.org/blog/chips-science-act-summary/

[25] IEA, Inflation Reduction Act of 2022, 11 December 2023, https://www.iea.org/policies/16156-inflation-reduction-act-of-2022#

Climate Adaptation Is Also A Public Good, Though a More Local One

As with mitigation technologies, most adaptation technologies are also public goods. That is, they can have high public (non-private) returns, low/er commercial returns, produce positive externalities, and benefit from economies of scale. **However, unlike mitigation technologies, many adaptation technologies 'public goods' aspects are local/national rather than international in character**. The local/national character of most climate adaptation means that they can be well-suited for local or national-level planning, contracting, and financing. It also implies that public investments in climate adaptation may align with the rising tide of anti-globalization and resource nationalism.

Being a public good does not mean that climate adaptation technologies will be easy to implement. First, beyond academia and the climate community, knowledge about adaptation technologies is still limited, and awareness and understanding among investors and stakeholders remains low. Second, many adaptation projects are of a long-term nature, with quite a few facing a 10-20 year implementation horizon. Third, average project size is *typically* relatively small, around $30-50 million, according to 2023 World Resources Institute estimates[26]. Fourth, a lack of clear quantification of risks to physical systems hampers a cost-benefit analysis and a net present value analysis needed to effect a "technocratic" determination of economic viability. **Indeed, adaptation investment remains at an analytical disadvantage to mitigation, because whereas mitigation could have an observable price via the market price of carbon credits or offsets, the price of the output of a public investment in adaptation can only be inferred.**

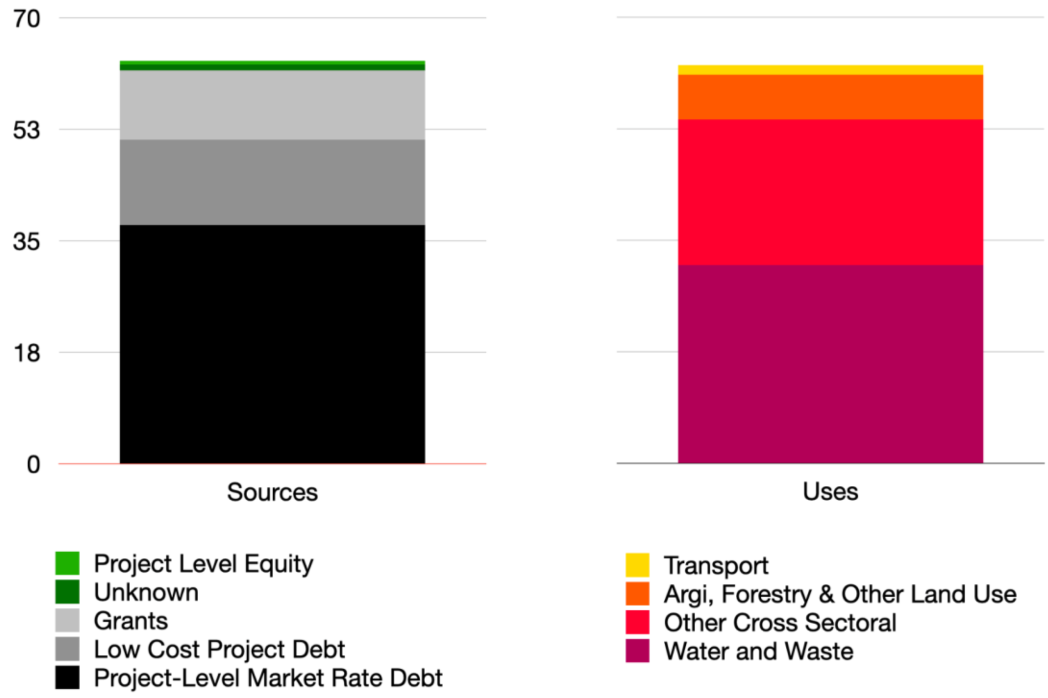
While several risk management services, for example, Moody's RMS Intelligent Risk Platform and dClimate's Aegis platform, already attempt to quantify the physical risks to assets from climate-related disruptions, these systems are often constrained by the limitations of modelling future weather patterns, imperfect knowledge of engineering specifics, and the intractability of putting a pecuniary value on business interruptions that will take place in the future. As a result, point estimates of the expected losses the systems deliver may come with a very large standard deviation, leading to high variability of the expected return on an investment in adaptation, and thus a very high "discount factor" imputed for private returns. The 2024 World Economic Forum Global Risk report highlights that, generally speaking, climate-risk models, whether public, private or academic, do not adequately capture *nonlinear* impacts or interconnectedness of climate systems, failing to answer how cascading effects from the passing of one tipping point could lower the critical threshold for others[27] (leading to risk multiplication). The report indicates, for example, that the "melting of the Greenland Ice Sheet could lead to an influx of fresh water, destabilizing the Atlantic Meridional Overturning Circulation (AMOC) and creating conditions that melt the West Antarctic Ice Sheet faster."[28] **Nonlinear model effects, of course, do not lend themselves easily to private capital budgeting and planning.**

[26] World Resources Institute, What It Takes to Attract Private Investment to Climate Adaptation, 10 May 2023, https://www.wri.org/insights/private-sector-climate-adaptation-finance

[27] World Economic Forum, The Global Risks Report 2024, https://www.weforum.org/publications/global-risks-report-2024/

[28] Ibid.

Exhibit 6: Adaptation Financing, 2021-2022, $ Billion: Sources and Uses



Source: Climate Policy Initiative, Macquarie Group, SMU/SKBI, Turning Point Macro

These complications may be why, despite avowed benefits, the deployment of - and funding for - the adaptation technologies has been severely lacking. According to the 2023 report by Climate Policy Initiative, only 5% of the "tracked" 2021-2022 annual climate finance - or USD 63 billion - was earmarked specifically for adaptation.[29] **As a result, current tracked adaptation commitments stand at 17 times less than the estimated USD 1.1 trillion per annum requirement** for the adaptation financing between 2021–2030, specified in the Nationally Determined Contributions (NDCs) (submitted to the UN by signatories of the Paris Climate Accords).[30]

Pre-Funding "Climate Liabilities"

If climate mitigation fails to deliver on the "net zero" target - as we expect it will - while climate adaptation investing does not gain momentum - each society will face a double crisis by 2050: a warmer climate plus what can be called "unfunded climate liabilities" - borne by both the future generations as well as the current generation, in old age. To borrow from the pension investment

[29] Climate Policy Initiative, Global Landscape of Climate Finance 2023, November 2023, https://www.climatepolicyinitiative.org/wp-content/uploads/2023/11/Global-Landscape-of-Climate-Finance-2023.pdf

[30] Climate Policy Initiative, State and Trends in Climate Adaptation Finance 2023, https://www.climatepolicyinitiative.org/wp-content/uploads/2023/12/State-and-Trends-in-Climate-Adaptation-Finance-2023_.pdf

analogy, a certain amount of funding is required to ensure that humanity's standard of living is not lower 26 years from now than it is in 2024, or at least that humanity's standard of living is "smoothed", whereby a standard-of-living sacrifice is made today in order to ensure that a larger standard of living shortfall is not experienced in the future. Standard-of-living smoothing (really, consumption smoothing) for an individual is the basis for the use of pension funds in societies in which retirement exists. Similarly, funding a future climate liability today (at a societal level) can also ensure that "smoothing" happens at a societal level. **The pecuniary gap between what has already been invested in (or funded) vs. what will be required to further "smooth" standards of living, is the unfunded climate liabilities gap.**

Once a government has decided to fund this gap (i.e., to pre-fund it), it can do so only in limited ways. These include borrowing against its own credit (thereby diverting a portion of society's savings), or diverting revenues from taxation or revenue windfalls (including, perhaps, taxes on carbon emitters). Alternatively, to extend the private pension analogy, individual climate-fund accounts can be set up, under the right regulatory structure. Either way, such plans would require a redirection of society's resources away from consumption or investment (in other projects) and towards building out a fund to defray or defease the present value of future "liabilities". **Given high climate uncertainties - and potentially extremely high mitigation and adaptation costs - we believe that pre-funding climate on a national level would be the most effective option.**

We suggest doing so by setting up dedicated Sovereign Climate Funds (SCFs) - structures similar to Sovereign Wealth funds (SWFs), but with a climate mandate specifically. In our view, sovereign climate funds could become the key vehicle through which public finance ensures future climate resilience.

The Case For Sovereign Climate Funds

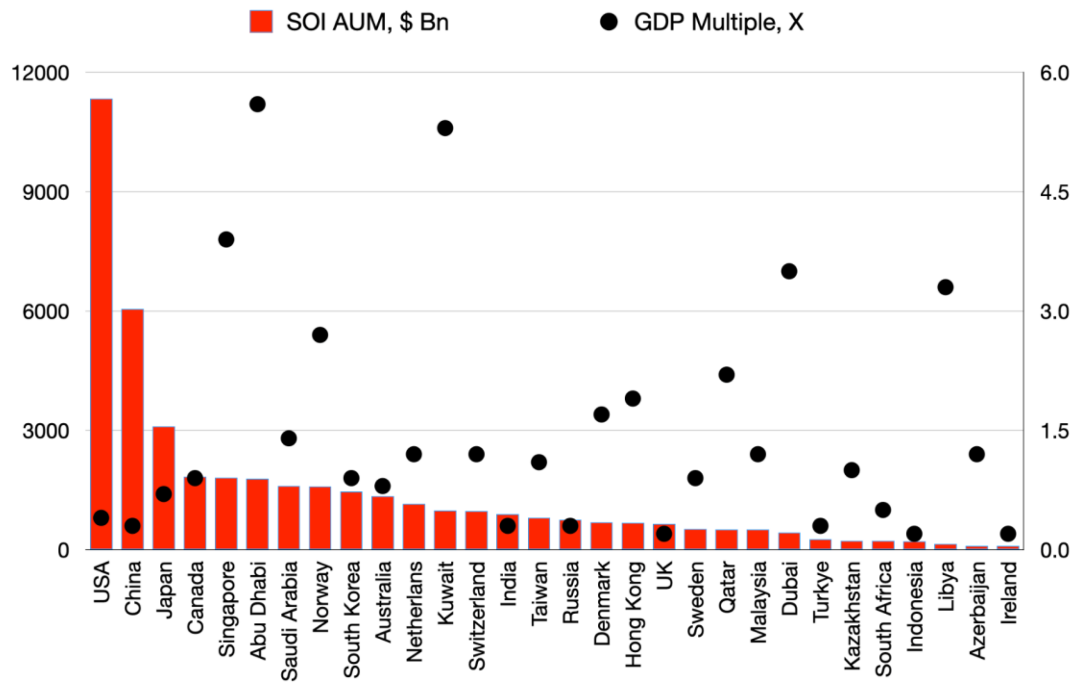
Of course, the issues facing a sovereign agency undertaking investment in climate are no less complicated than those facing the private sector. A sovereign must also base its decisions on a capital budgeting analysis that maximizes the investment returns, and conduct a probabilistically-based cost benefit analysis and opportunity-cost analysis. **Sovereign agencies, however, have at least two advantages investing in local public goods.**

First, sovereigns are more cushioned against bankruptcies than private institutions, given a government's ability to generate fiscal surplus by collecting taxes and accumulating foreign exchange reserves and proceeds from sales of state-owned assets. As a result, a sovereign can typically access capital at a cheaper cost than the private sector, allowing them to put less consideration on a "risk premium" in their capital budgeting.

Second, projects that are not economically viable when considered for their commercial benefits alone can become economically viable when a sovereign takes into account their social benefits (returns), especially as a prerequisite for wider or more sustainable economic growth. National governments can also incentivize the private sector to invest into adaptation projects through policies, regulations, and financial incentives.

Critically, for climate, sovereign investing is already flourishing. The world's first dedicated Sovereign Wealth Fund - the Kuwait Investment Board - was set up over 60 years ago, in 1953, by Sheikh Abdullah Al-Salem Al-Sabah, with the expressed mandate to promote national welfare and sustainable development by investing Kuwait's excess oil revenues. Currently, there are 653 sovereign investors worldwide, including Sovereign Wealth Funds, Central Banks and Public Pension Funds.[31] Collectively, these investors manage around USD 49.7 trillion in assets. When counted on their own, the world's 100 largest SWFs command between US 11.4 trillion assets under management (AUM, Global SWF estimates) and US 12.3 trillion AUM (SWF Institute estimates)[32]. Global SWF expects SWF AUM to grow to at least US$ 12.7 trillion by 2025, and US$ 18.0 trillion by 2030. **This presents a large pool of assets to start the work that Sovereign Climate Funds must undertake.**

Exhibit 7: State Owned Investors Assets Under Management: Total vs Relative to GDP



Source: GlobalSWF, Macquarie Group, SMU/SKBI, Turning Point Macro

What, then, makes Sovereign Wealth Funds - as compared to Central Banks or Public Pension Funds (the other kinds of sovereign investors) - a suitable model to follow for sovereign climate investing? First and foremost, it is the flexibility of their mandates and structures.

SWFs are a heterogeneous group, straddling the entire spectrum of objectives. These range from macro stabilization funds (which focus on shielding the countries from economic or political shocks), to intergenerational savings funds (to cater to the emerging costs of the elderly population), to reserve investment funds (targeting long term investments with high yields), to pension reserve funds (without explicit pension liabilities), to development funds (that mandate investing in domestic infrastructure and

[31] Global SWF, 2024 Annual Report, https://globalswf.com/reports/2024annual#sois-2030-9.

[32] SWF Institute, Top 100 Largest Sovereign Wealth Fund Rankings by Total Assets, Accessed on 2 March 2024, https://www.swfinstitute.org/fund-rankings/sovereign-wealth-fund

nascent technologies to promote broad-based development). The differences in SWF objectives also lead to differences in their investment styles (from short-term focused, with highly liquid portfolios, to long-term focused, with more illiquid diversified portfolios) and return criteria (including willingness to de-prioritize financial returns to reach development goals). Further, SWFs can follow one of several legal frameworks, starting with a separate legal entity (with full capacity to act independently under a specific constitutive law) and going all the way to a legally-separated pool of assets but without the legal structure of independence (e.g. administered by a state agency).[33]

The other points to consider are SWFs' typically long-term investment horizon and relative political independence. The investment horizons of projects related to climate threats often stretch beyond the timescales often relevant to governments in traditional democracies, where electoral cycles typically range from four to six years. Unfortunately, electoral priorities can sometimes shift the emphasis in government's decision-making, and impact problem identification and solving. Hence, placing the dedicated climate funds in a "long-dated" SWF rather than a "short-dated" government agency may help ameliorate the scale mismatch problem.

As a group, SWFs have also been known to deliver superior investment returns. While all SWFs report performance in different fashion, their annualized returns between 2013 and 2022 averaged 6.6% vs 5.0% return for a "traditional" 60/40 equity/fixed income mix.[34] **This could help deflect criticisms that SWFs introduce an unneeded bureaucratic or politically-derived wastefulness.** One star SWF - New Zealand's Super - outperformed even S&P 500, a pure equity benchmark, generating 12.1% pa between 2013 and 2022, vs 10.0% for the S&P.[35]

Further, developing Sovereign Climate Funds also fits with the recent trend of new SWF creations. For example, five new SWFs were created in just the past 12 months: the Maharlika Investment Fund in the Philippines, Hong Kong Investment Corporation, Pakistan's PSWF, Kosovo's SFR and Mozambique's FSM. Several other funds are readying for launch, including Dubai Investment Fund, Colombia Public Wealth Fund, Peru Sovereign Wealth Fund, Future Ireland Fund, Portugal Sovereign Wealth Fund, Kuwait Ciyada Development Fund, and Oman Future Fund, Brazil Fundo Social Pre-Sal, Italy Sovereign Fund.[36]

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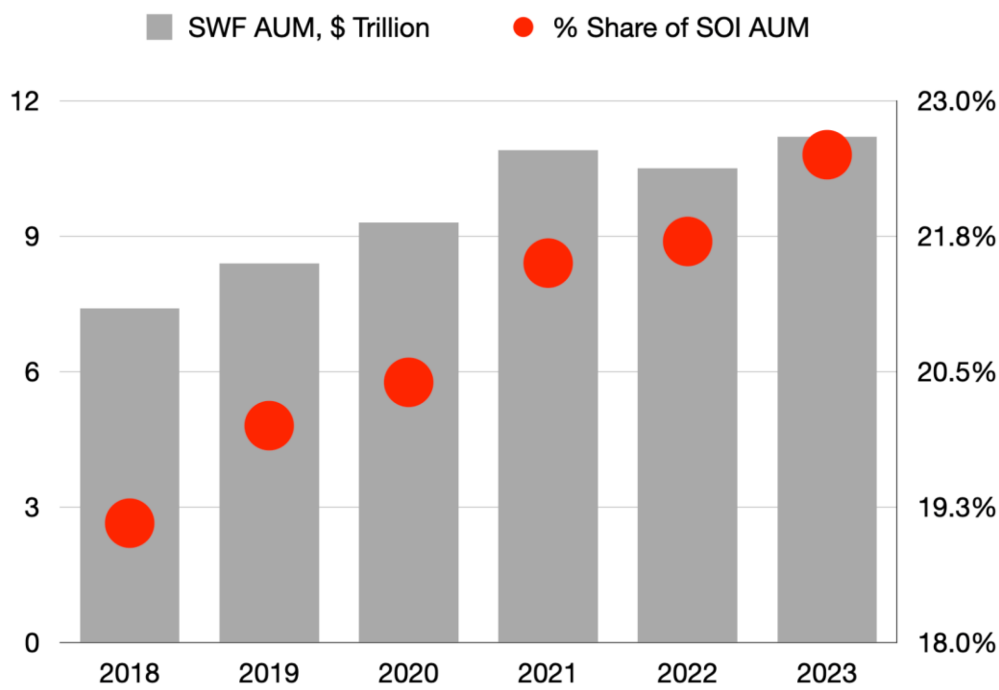
[33] For more details, see Khalid Alsweilem, Angela Cummin, Malan Rietveld, Katherine Tweedie, Sovereign Investor Models: Institutions and Policies for Managing Sovereign Wealth, Harvard Kennedy School, 2015, https://projects.iq.harvard.edu/sites/projects.iq.harvard.edu/files/sovereignwealth/files/investor_models_final.pdf

[34] Global SWF, 2024 Annual Report, https://globalswf.com/reports/2024annual#sois-2030-9.

[35] Ibid

[36] Ibid

Exhibit 8: Sovereign Wealth Funds Asset Under Management, Total vs % SOI AUM



Source: GlobalSWF, Macquarie Group**,** SMU/SKBI, Turning Point Macro

Key Considerations For Setting Up Sovereign Climate Funds

What, then, should be the key considerations for structuring sovereign climate funds? The first consideration would be to determine the target size of the SCF, an exercise analogous to calculating the nation's unfunded climate liability. In principle, this can be calculated as the (properly discounted) accumulated shortfall to real GDP vis-a-vis a multi-year baseline achievable without climate change. Thus, unlike a traditional SWF, which has its origin in a financial windfall that has benefitted a society, SCFs need to begin by acknowledging the unfunded climate liability and the funding needed to cover it. While the start of an SWF is usually asset-side driven, SCFs would be liability-side driven.

The second consideration would be to determine the SCF mandate(s), structure, and investment strategy(ies), all of which must be aligned with the country's climate liability size and climate risk profile. Theoretically, a SCF can make many investments related to climate. But if we follow the theme that SCFs are intended to help "smooth" out the short-term variability and long-term erosion in welfare that would otherwise result from climate events and change, then it will be helpful to divide an SCF's investment program into two pillars:

> (1) **investments in liquid assets (reserves), which are committed to the provision of relief to national communities struck by climate-related events.** Such reserves can finance a contingency fund that would transfer value to government budgets in case of climate-related harm. They could also be contributed to "risk pools" that mutualize the risks faced by many countries (and

generate a return). Further, liquid reserves can serve as collateral against the issuance of catastrophe bonds by the country.

(2) **investments in technologies and infrastructure that can help foster resilience to climate-related welfare losses in the future.** These investments would be modelled on the development SWFs, but with the climate-oriented mandate and with far greater allocation towards (illiquid) strategic investments (including in infrastructure), 'green' fixed income, and venture capital and private equity.

The third consideration would be to delineate sources of SCF funding. Similar to SWFs, SCFs can be funded through commodity, fiscal, and asset sales windfalls - as well as by issuing debt. As an example, according to Reuters, SWF debt issuance has become a rising trend post COVID-19, as subdued commodity prices, weaker economic activity, and large fiscal responses diminished the government budgetary surpluses.[37]

The fourth and final consideration would be to design SCF accumulation and spending rules, including how the accumulated assets should be transferred to beneficiaries in the event of a climate-related loss. The SCF accumulation rules would be especially critical in determining funding priorities of, for example, the contingency fund vs the climate risk pool vs the development pillar, to ensure that the relationship between them as well as the allocation priorities are delineated. Further, to use as examples the spending approaches deployed by SWFs, some SCFs will spend only the investment returns while preserving capital, while others reinvest the portion - or all - of the investment income until a target AUM level is reached.

What Investments Could Sovereign Climate Funds Make?

Focusing on the two pillars, we consider below examples of investments that SCFs *could* make. This list is non-exhaustive, being offered to stimulate the debate and discussion of the appropriate investment mandates of SCFs that are developed in the future.

1. **Investing in Liquid Assets for Reserve Funds.** In an ideal world, the risks coming from climate variability should be managed by transferring the bulk of the risk through mutualization mechanisms (i.e., risk pooling) or other risk transfer modalities (e.g., catastrophe bonds). Those risks that are high-frequency and low-severity, or can't be modelled should be retained. Traditionally, countries that would retain such risks would use government budgets to cover disaster recovery and reconstruction needs following climate events. **However, as both the frequency *and* severity of climate disasters grow, an SCF could create a dedicated and segregated climate contingency reserve fund inside the SCF, and invest these reserves in liquid assets, for example, treasury bills.** The investment income and principal contributed to such a fund can then be used to disperse aid quickly following climate disasters, and without the hindrance of budgetary-

[37] Tom Arnold, Sovereign funds seek to raise debt and equity as pandemic strains state budgets, Reuters, 28 October 2020, https://www.reuters.com/article/swf-funding/sovereign-funds-seek-to-raise-debt-and-equity-as-pandemic-strains-state-budgets-idUKL8N2HE37G/?edition-redirect=uk

political mechanisms, to ensure greater resilience. Of course, amassing the *adequate* climate contingency (reserve) fund may not be possible for every nation - especially those with existing high levels of debt.

2. **Participation in Global Climate Risk Pools.** In addition to climate contingent reserves *inside* an SCF, an SCF can *transfer* some climate risk via *participation* in climate risk pools. Here an SCF would contribute part of the collateral to a pool, to be used to cover all participants against specified climate perils. Four *regional* sovereign climate risk pools, seeded primarily by multi-donor grants via The World Bank, already exist. They are the Caribbean Catastrophe Risk Insurance Facility (CCRIF SPC), the Pacific Catastrophe Risk Insurance Company (PCRIC), the African Risk Capacity (ARC); and the Southeast Asia Disaster Risk Insurance Facility (SEADRIF), all of which have been operational for the past decade and a half. All four are also based on a parametric insurance model, where the payout is linked to specific measurable and certifiable climate events (such rain, extent of flood zone, heat, temperature, etc.) and made very rapidly (between 7 and 14 business days), as it doesn't depend on a lengthy adjustment process.[38] **According to the World Bank, regional risk pooling can lead to 45% reduction of the capital required to sustain a 1-in-200 year loss and a 52% reduction of the capital required to sustain a 1-in-250 year loss, compared to the sum of values for individual countries.[39] We believe that if climate risk pooling becomes global (i.e., better diversified across geographies and perils), the capital reduction benefits would be even greater. Additionally, large and diversified risk pools allow for an efficient transfer of excess risk to reinsurers and the capital markets.** For example, in the 2015/16 policy year, ARC retained only about US 22.5 million of risk through its reserves and passed a further US 72.5 million to reinsurers.[40]

3. **Investing in Municipal or Local Climate Adaptation Bonds.** The task of building large-scale adaptation infrastructure projects has often been managed by the local governments, especially in the cities that have the most exposure to climate change, owing to their population density, proximity to water, and the risk multiplier implicit in overlapping systems of public goods and public service provision.[41] Such localities can issue climate adaptation-revenue bonds, which the SCFs, in turn, can become buyers of. By having a large pool of the SCF capital at their service, municipalities can better access credit and improve the effective cost of the bonds (thus lowering the user fees paid to the local governments, e.g. in the form of taxes). Of course, a tax surcharge (especially, if applied to properties exposed to climate dangers on a progressive scale) would also serve as an incentive mechanism to dissuade businesses and households from expanding or building in at-risk areas. While some municipal adaptation bonds are already being issued (for example, in February 2024 India's Vadodara Municipal Corporation (VMC), launched India and Asia region's first globally certified green municipal bond in the amount of Rs. 100 crores (USD 12

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38 World Bank Group, Sovereign Climate and Disaster Risk Pooling, 2017, https://www.gfdrr.org/sites/default/files/publication/WB%20DRFIP_Cat%20Risk%20Pool%20for%20G20_full%20report.pdf

39 Ibid.

40 Ibid.

41 Francisco Estrada, WJ Wouter Botzen, Richard SJ Tol, A global economic assessment of city policies to reduce climate change impacts, Nature Climate Change, 29 May 2017, https://www.nature.com/articles/nclimate3301

million), to enhance liquid wastewater management infrastructure[42]), the market is still at its nascency. In 2022, the municipal green bonds (MGBs) segment - which includes *both* climate adaptation and climate mitigation bonds - reached only US 136 billion globally, according to WEF estimates.[43] By comparison, S&P Global Ratings expects full year 2024 sustainable green, social, sustainability, and sustainability-linked bond (GSSSB) issuance to reach US 1.05 trillion, and even that is just 12-14% of the fixed income issuance total.[44] **There is plenty of room for municipal adaptation bonds to expand their reach into the capital markets.**

4. **Invest in Climate Venture Capital and Private Equity.** A way for sovereign climate funds to start empowering *emerging* climate technologies would be to make venture capital (VC) and private equity (PE) investments into those technologies. As is with traditional VCs, SCFs could then serve as shepherds of strategic innovation, providers of "bridge" capital to turn entrepreneur ideas into reality, and critical validators of the technical feasibility and potential for commercial success of various start-up ideas. They could also become the overall engines of the startup ecosystem growth in those technologies, and in adaptation technologies in particular. To promote early stage adaptation modalities (from pre-seed to Series A levels), where the investment "ticket" varies, on average, between US 25,000 and US 2 million and some SCFs may have trouble participating due to their size, the SCFs should further consider investing into dedicated *existing* climate VC and PE funds, to act as the force multiplier. The most critical adaptation and dual use technologies the SCFs should stimulate with their investments include climate data (collection, processing and modelling), agricultural yield enhancement, materials sciences, and high efficiency/low output variability alternative energy sources (such as nuclear fusion and thorium-based fission). According to Preqin research, the 2020 median allocation of SWFs to private equity stood at only 9.3% vs median 13.4% target.[45] **The allocation to both private equity and venture capital will certainly need to be far higher for the SCFs, to spur the development of new adaptation technologies**.

5. **Make Direct Investments in Climate-Related Health Care Infrastructure and Resilient Real Estate.** At present, climate change is expected to adversely affect some of the basic needs of society's constituents - their physical health, the quality of habitation, and their access to food. A higher frequency of natural disasters, such as hurricanes, tsunamis, floods, wildfires and extreme heat waves can lead to physical and mental injuries, if not outright death. Indeed, the latest research indicates that 58% of the *known* human pathogens may be made more aggressive by climate

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[42] Climate Bonds Initiative, Vadodara Municipal Corporation Initiates India and Asia's First Certified Green Muni Bond for Sustainable Water Infrastructure, 29 February 2024, https://www.climatebonds.net/resources/press-releases/2024/02/vadodara-municipal-corporation-initiates-india-and-asias-first

[43] World Economic Forum, What are Municipal Green Bonds and how are global cities using them to finance green projects? 20 November 2023, .https://www.weforum.org/agenda/2023/11/heres-how-3-cities-are-using-municipal-green-bonds-to-finance-climate-infrastructure

[44] Patrice Cochelin, Bryan Popoola, Emmanuel Volland, Azul Ornelas, Sustainable Bond Issuance To Approach $1 Trillion In 2024, S&P Global Ratings, 13 February 2024, https://www.spglobal.com/_assets/documents/ratings/research/101593071.pdf

[45] Grant Murgatroyd, SWFs in Alternatives: in Pursuit of Higher Returns, Preqin, 26 May 2021, https://www.preqin.com/insights/research/blogs/swfs-in-alternatives-in-pursuit-of-higher-returns#

change via over 1,000 unique pathways.[46] Some scientists also worry that *unknown* pathogens lying dormant in permafrost could be released as the climate continues to warm.[47] Given the experiences of the COVID-19 pandemic, which stretched global healthcare *infrastructure* to the limit, and spread due to the lack of readily available treatments, we believe a special argument can be made for SCF direct investments in healthcare infrastructure and real estate, as part of the adaptation-development mandate. The presumption here, of course, is that public health is a public good and/*or* an income-transfer mechanism, already subsidized by governments in the OECD and elsewhere. While investments in healthcare are already a part of the SWF portfolios, these are largely undifferentiated and made without reference to the future healthcare needs that would arise should Paris-accord climate goals not be met. **The SCFs, thus, should make investments in healthcare with a particular view to addressing the health perils that would come under the adverse climate scenarios**, **including with greater prevalence of germs.**

6. **Make Direct Investments in Connectivity Infrastructure and Use "Blended" Finance.** Another adaptation infrastructure funding option is direct investment in climate-resilient connectivity infrastructure, including roads, seaports, and airports. Not all connectivity infrastructure is, of course, a public good - for example a toll road, financed by the user fees, can exclude free riders. Care, thus, must be applied to distinguish whether connectivity infrastructure generates positive externality and should be the mandate of a state agency. Main risks to the legacy connectivity infrastructure arising from change in rainfall patterns, wave heights, temperature variability, etc leading to floodings, disruptions of operation, weakening of materials and bearing capacity, etc and, thus, reduced safety and increased congestions. **For large climate adaptation infrastructure needs, sovereign climate funds can invest using various project finance models, including blended finance** - the approach when capital is derived from both private and public (or quasi-public, such as sovereign climate fund) sources, to mobilize private sector investment in what is, essentially, a public good, and to maximize development impact and outcomes. Traditionally, blended finance is designed to deliver market-based, risk-adjusted returns to private investors via re-allocation of risks - in part or in full - to the public/quasi-public sector. According to OECD guidelines, blended finance must insure additionality, i.e. be deployed only for uses where commercial financing is not available or where concessional financing is required.[48]

[46] Camilio Mora, Tristan McKenzie, IsabellaM Gaw, Jacqueline M Dean, Hannah von Hammerstein, Tabatha A Knudson, Renee O Setter, Charlotte Z Smith, Kita M Webster, Jonathan A Patz, Erik C Franklin, Over half of known human pathogenic diseases can be aggravated by climate change, Nature Climate Change, 08 August 2022, https://www.nature.com/articles/s41558-022-01426-1

[47] Tom Vanden Brook, The Arctic permafrost is 1,000 years old. As it thaws, scientists worry what it might unleash, USA Today, 18 November 2023, https://eu.usatoday.com/story/news/politics/2023/11/18/arctic-permafrost-thawing-deadly-pathogens/71581668007/

[48] OECD, Blended finance guidance & principles, Accessed on 20 March 2024, https://www.oecd.org/dac/financing-sustainable-development/blended-finance-principles/guidance-and-principles/

Summary

We presented above a case for the establishment of the Sovereign Climate Funds (SCFs), a new type of financial vehicle to complement Sovereign Wealth Funds. The main purpose of SCFs would be to address deficits in the public financing of technologies and development projects pertaining to adaptation (or resilience) to climate change. Thereby, SCFs can help "smooth out" current and future losses to societal welfare that climate change may produce, especially in view of the long-cycle effects of the Earth's warming. Like mitigation, adaptation modalities may have an important "public goods" aspect, which warrants public-sector involvement or subsidies directed towards it, and inter-generational approaches. But unlike carbon mitigation, which is generally an *international* public good, adaptation has mainly local positive externalities. That means that a country-level SCF, mandated to address a national deficit in public-goods provision of climate adaptation, can have a purpose-built investment mandate around managing a country's specific exposure to climate perils. We envision investment programs for SCFs that are directed at two pillars: (1) a highly liquid assets (reserves) pillar committed to provision of relief to national communities struck by climate related events and (2) a less liquid development pillar, focusing on growing technologies and infrastructure that can help foster resilience from climate related losses in the future. Of course, when adaptation projects can combine with mitigation projects, or other societal benefits (such as environmental benefits), the case for public investments in those projects only grows.