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Leveraging Environmental Reserve Assets to Achieve a Sustainable Environment

Tamim Ephrem Akiki

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by Tamim Ephrem Akiki

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PLAGIARISM STATEMENT

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ABSTRACT

This paper proposes a financing mechanism that seeks to realize massive projected returns associated with holding global warming at below 1.5°C above pre-industrial levels. The IMF and national authorities of every participating country design 20-year Structural Environmental Adjustment Plans (SEAPs) that include preservation targets, emissions reductions, and investment budgets. Those budgets can either be self-financed or, where need is demonstrated, funded by the IMF using zero-interest loans that fully amortize through environmental outcomes. Maximum funding capacity is measured using Special Environmental Drawing Rights (SEDRs), an indefinite potential claim on the IMF's freely usable currencies for climate finance regardless of future changes in global economic and financial power structures.

Keywords: Climate Change, International Monetary Fund, Special Environmental Drawing Rights, Structural Environmental Adjustment Plan, Environmental Reserve Assets

JEL Classifications: F18, F31, F33, F34, F35, B25, Q2, Q5, Q43

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II. LIST OF TERMS, ACRONYMS, AND DEFINITIONS

Accrued ERAs: Improvements in Environmental Reserve Assets achieved under a Structural Environmental Adjustment Plan (SEAP). Increases in accrued ERAs are equal to reductions in potential ERAs. At the end of any 20-year SEAP, accrued ERAs are used to calculate maximum access to IMF zero-interest environmental loans.

Actual ERAs: Actual ERAs refer to a country's environmental standing at the start of its transition under a SEAP. Actual ERAs include forest areas, marine and terrestrial protected areas, and numbers of endangered species. After a 20-year SEAP is fully implemented, actual ERAs become part of accrued ERAs and are no longer measured separately.

Accrued SEDRs: Special Environmental Drawing Rights are accrued at the end of each SEAP and add to a country's international reserve assets. They grant a participating country the right to access zero-interest 20-year loans from the IMF along with the right to repay by maintaining its existing environmental outcomes. The maximum loan size is determined by the value of accrued ERAs plus related activities.

CDM: Clean Development Mechanism

ERAs: Environmental Reserve Assets are defined as the country's actual environmental wealth plus potential increases in forest areas, populations of endangered species, and marine and terrestrial protected areas, and potential reductions in greenhouse gas emissions, freshwater abstracted, and unrecycled hazardous waste production.

EGR: The Emissions Gap Report is an annual publication by the United Nations that compares global GHG emissions, forecasts, and targets to the levels required to avoid the worst impacts of climate change.

GHGs: Greenhouse gases are those gases designated by the IPCC as absorbing infrared radiation and contributing to the greenhouse effect. Examples include carbon dioxide, nitrogen oxide, methane, chlorofluorocarbons, and sulfur fluoride.

IMF: International Monetary Fund

IPCC: The Intergovernmental Panel on Climate Change is a United Nations body that provides objective and scientific views of climate change issues and response options.

NAMA: Nationally Appropriate Mitigation Actions

Natural base: An aggregate measure of a country's environmental standing with respect to forest areas, numbers of endangered species, marine and terrestrial protected areas, the amount of greenhouse gas emissions, freshwater abstracted, and unrecycled hazardous waste production.

NDCs: Nationally Determined Contributions

Potential ERAs: The range of feasible improvements in ERAs as determined by SEAPs. Improvements include increases in forest and protected areas, recoveries of endangered species, reductions in GHGs, and others.

Relative GHG reductions: Reductions in excess of the global trend during a 20-year SEAP. A country whose emissions reductions exceed the global trend receives additional accrued ERAs at the end of the SEAP with a weight factor of 2%.

SEAP: A Special Environmental Adjustment Plan refers to a detailed reform strategy agreed between a participating country and the IMF with the aim of preserving existing natural assets and improving environmental outcomes over a 20-year period. SEAPs are mandatory for countries seeking to accrue Special Environmental Drawing Rights (SEDRs) by borrowing from the IMF or through self-financing.

SEDRs: Special Environmental Drawing Rights are the unit of measurement used to calculated a country's maximum capacity to leverage its ERAs to borrow at 0% for 20 years from the IMF for environmental projects and to amortize that loan using real environmental outcomes. Each SEDR, which is equal to 1 SDR, is a potential claim on the IMF's freely usable currencies.

SDRs: Special Drawing Rights are the IMF's unit of account. Their value is calculated daily using a weighted linear combination of the market prices of the IMF's five reserve currencies: the US Dollar, the Euro, the British Sterling, the Japanese Yen, and the Chinese Renminbi. IMF members are assigned SDR quotas which serve as a reserve asset and liability.

UNFCCC: United Nations Framework Convention for Climate Change

III. INTRODUCTION

This paper proposes a financing mechanism for a global response to climate change through a commitment by every member of the IMF to environmental preservation. Countries set preservation targets and investment budgets under 20-year Structural Environmental Adjustment Plans (SEAPs) developed in collaboration with an environmental department at the IMF; plans may be funded by borrowing directly from the Fund. Special Environmental Drawing Rights (SEDRs) determine the maximum access any country can have to a 20-year, zero-interest loan fully amortized through environmental outcomes. Countries that self-finance environmental projects under SEAPs and achieve their targets also accrue SEDRs, representing a potential claim on the IMF for climate finance.

Stern (2006, in Stein and Sietchiping 2010, 22) describes climate change as "a problem of intertemporal international collective action with major uncertainty and linked market failures." SEDRs offer an answer to that challenge; they represent a joint commitment by every country to make financing available to protect and conserve the planet independent of future changes in economic and financial power structures. The returns from keeping global warming less than 1.5°C over pre-industrial levels are immense and none of the current climate financing mechanisms have been able to mobilize sufficient financing to effectively meet that challenge. The effects of climate change on global output are also contractionary and widespread, while the transition poses substantial challenges to the payments balances of developing countries that carbon taxes would not address. This paper argues that the IMF's mandate requires proposals for it to respond to climate change and proposes an adaptation of its Special Drawing Rights (SDRs) to make climate financing available to any country that needs it, in the spirit of comments by William McChesney Martin, Chairman of the Board of Governors of the Federal Reserve System at the time of the SDR creation, who stated that "change, development, progress are the law of life. There is no reason for any of us to insist on maintenance of the status quo. Although the present international monetary system has served the world well, it, like all institutions, must evolve and adapt to changing circumstances" (Martin 1965, 10).

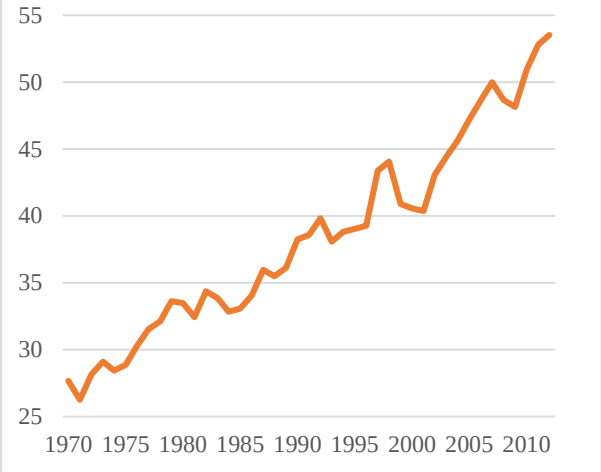
SEDRs combine concepts from the IMF's SDRs with features from John Maynard Keynes's International Clearing Unit proposal, Nicholas Kaldor's commodity reserve currency proposal, and developing countries' proposed "link" during SDRs debates in the 1960s. All four approaches recognized risks to global and national economic objectives from unchecked current account imbalances and from insufficient access to development finance by developing

countries, placing all proposed responses within the scope of the IMF. Unlike Kaldor's commodity buffer stocks, SEDRs are derived from environmental reserves which have positive global returns while still granting deficit countries a claim on the reserves of surplus countries contingent upon environmental outcomes. In the past, debt-for-nature swaps granted external donors some influence over forest areas in developing countries; SEDRs internationalize the influence by conditioning the accrual of SEDRs, even if self-financed, on similar indefinite terms for the maintenance of environmental outcomes. They set a floor on environmental standards by removing incentives for countries to achieve trade gains through a mutually-destructive race to a climate bottom. They mark the "highest possible ambition" and deliver on "common but differentiated responsibilities and respective capabilities, in the light of different national circumstances" as stipulated by the Paris Agreement (UNFCCC 2015, 4).

IV. CLIMATE CHANGE DYNAMICS AND RESPONSE

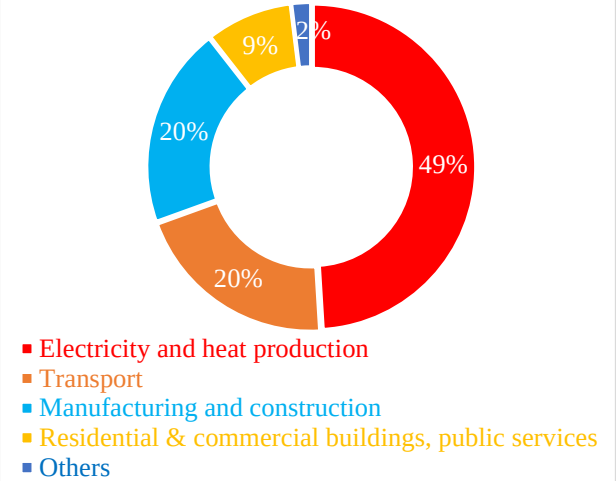
Climate change and environmental conservation are global challenges that require a global response. Increases in the emissions of man-made greenhouse gases (GHGs) into the atmosphere disturb the Earth's radiative balance, leading to an increase in the surface temperature with a wide range of climatological effects, especially on sea levels and agriculture. Yet, global annual GHG emissions doubled to 53.5 gigatonnes of carbon dioxide equivalent ($GtCO_2e$) in the forty-year period through 2012 (Figure 1), an aggregate figure that includes CO_2 totals and all anthropogenic methane (CH_4) sources, nitrous oxide (N_2O) sources and F-gases (hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6), and perfluorocarbons (PFCs)). Carbon dioxide makes up more than 76% of greenhouse gases contributing to global warming and climate change, followed by methane and nitrous oxide with 16% and 6% respectively (IPCC 2014). The latest preliminary data point to acceleration in GHG emissions in 2018 to 2.7% after relative stability in the period between 2014 and 2017 (Quéré et al. 2018).

Figure 1: Global GHG emissions ($GtCO_2e$)



Source: EDGAR

Figure 2: Global CO_2 emissions by sector

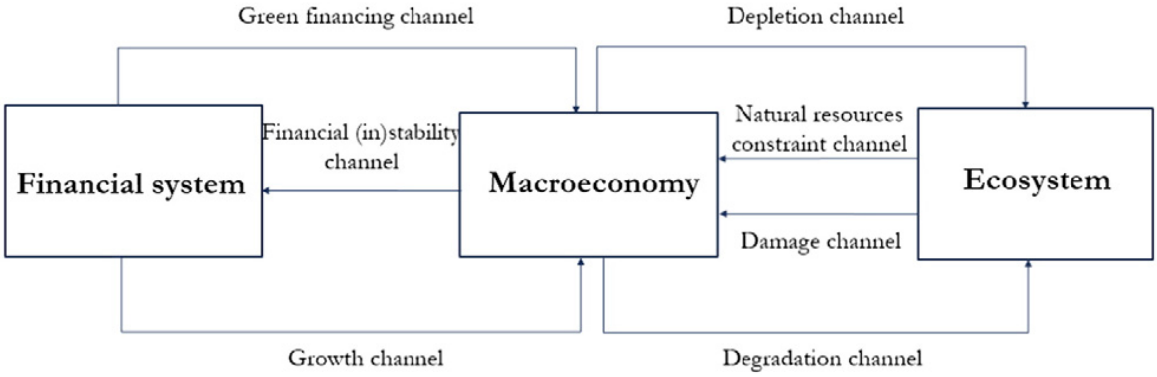


Note: From fossil fuel combustion in 2014.
Source: World Bank

The impact of climate change on human well-being and biodiversity has been well-documented, but evidence of the sizeable, widespread, and disproportionate economic costs of global warming has only recently emerged. Burke et al. (2018) find a more than 75% chance that global economic damage would be lower through 2100 if global warming was limited to 1.5°C

rather than to 2°C, with a 60% chance that the accumulated global benefits[1] would exceed US$20 trillion at 2010 prices under a 3% discount rate. They also find that an estimated 90% of the world's population and 71% of countries have a more than 75% chance of experiencing reduced economic damages at 1.5°C relative to 2°C. Signatories to the UN's Paris Agreement held in 2015 pledged to hold global temperatures at "well below 2°C above pre-industrial levels" by 2100 and to pursue a 1.5°C target (UNFCCC 2015, 3). Beyond 2°C, Burke et al (2018) show that the size of incremental damages is disproportionally higher, suggesting considerable risk to global output from missing climate targets, particularly when taking into account unprecedented extreme outcomes, such as large-scale sea level rise, that are difficult to predict because the world may only experience them at higher temperatures. Possible shocks emanating from the transition to a low-carbon economy pose major risk to financial stability as investors re-valuate carbon-intensive assets, and those risks may be even more significant when factoring in supply constraints to growth due to the exhaustion of natural resources. Dafermos et al. (2017) develop a stock-flow-fund ecological macroeconomic model that incorporates those physical risks linked to economic damages from climate-related events (Figure 3).

Figure 3: Main interactions between the ecosystem, financial system, and macroeconomy



Source: Dafermos et. al (2017)

Using their stock-flow model with physical constraints, Dafermos et al. (2018) find that firms' capital and profits will take a blow from climate change, leading to gradual deterioration in their liquidity and to higher default rates that could harm financial and non-financial corporations.

[1] Defined by the authors as the value of avoided impact.

The resulting portfolio reallocation would also cause a gradual decline in corporate bond prices, and climate-induced financial instability would adversely affect credit expansion. Similarly, Bovari et al. (2018) predict severe economic consequences resulting from the impact of climate change on economic fundamentals in the absence of proactive climate policies or in the event of a fast transition to a low-carbon economy. They find that global warming raises risks to financial stability by forcing the private sector to employ leverage to compensate for output and capital losses.

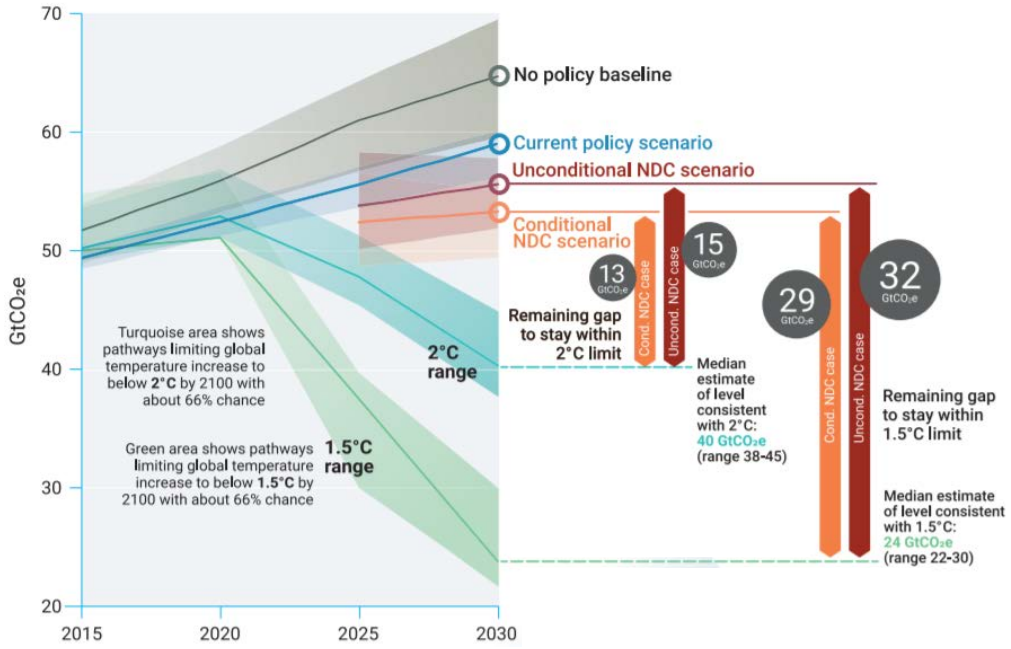
The response to climate change challenges has been global, with the UNFCCC acting as the center for developing international principles of climate change laws, culminating in the Paris Agreement, an international treaty signed by 195 members of the UNFCCC. Signatories called for the "highest possible ambition" and recognized "common but differentiated responsibilities and respective capabilities [CBDR&RC], in the light of different national circumstances" (UNFCCC 2015, 4). A central element of the agreement is that parties would develop nationally determined contributions (NDCs), defined by the UNFCCC as plans that highlight actions, targets, policies, and measures that governments will implement in response to climate change and as a contribution to global climate action. NDCs may be unconditional, voluntary and feasible without outside support, or conditional, involving more ambitious targets that depend on external support, primarily in the form of financial assistance.

The agreement also recognizes the role of financial flows in the achievement of targets, calling for flows "consistent with a pathway towards low greenhouse gas emissions and climate-resilient development" (UNFCCC 2015, 3). Financing for developing countries would take place under the Financial Mechanism through the Green Climate Fund, the Global Environment Facility, the Least Developed Countries Fund, the Special Climate Change Fund, and the Adaptation Fund set up under the Kyoto Protocol. Developed countries had already committed at the Copenhagen climate conference in 2009 to collectively contribute US$100 billion of climate finance per year by 2020; in Paris, they pledged to maintain or increase those financial resources through 2025. In addition, the agreement sanctioned the provision of additional financial resources outside the Financial Mechanism, potentially through bilateral agreements. Meanwhile, a smaller number of countries joined REDD+ (Reducing Emissions from Deforestation and Forest Degradation), another UNFCCC initiative, which encourages developed countries to provide technical and financial support to developing countries seeking to reduce emissions and enhance the removal of greenhouse gases through forest management

options. In one case, Norway pledged in 2010 to allocate up to $1 billion to support Indonesia's efforts under the REDD+ framework subject to measurable and verifiable national deforestation and emissions data (Norway and Indonesia 2010). In early 2019, Norway announced that it would release a results-based payment to Indonesia after estimates of forest emissions showed the latter had considerably slowed its deforestation rate (Seymour 2019).

Despite the abundance of channels for climate finance flows, the size of financial resources has remained inconsistent with Paris Agreement climate targets. The UN's 2018 Emissions Gap Report found that even if nations were to live up to their current commitments under both conditional and unconditional NDCs, global warming would likely come in at around 3°C by the end of the century, double the goal in the Paris Agreement (Figure 4). In the interim, current commitments expressed in the NDCs are inadequate to bridge the emissions gap by 2030. If NDC ambitions are increased, exceeding the 1.5°C target can still be avoided (EGR 2018).

Figure 4: Global GHG emissions and the emissions gap



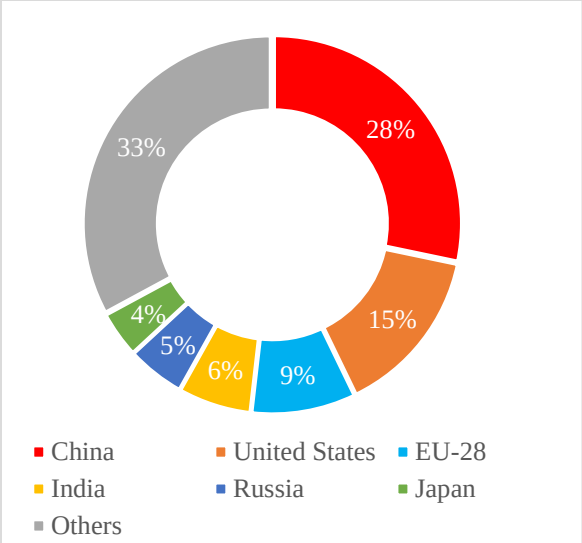
Note: Median estimates and 10th to 90th percentile range.
Source: United Nations Environment Programme, Emissions Gap Report 2018

Bovari et. al (2018) report more pessimistic findings. They argue that even the less ambitious 2°C target is already out of reach in the absence of negative emissions, and call for the implementation of an adequate carbon price trajectory, increasing the wage share, fostering

employment, and reducing private debt to help reach a more likely target of 2.5°C by 2100. Indeed, McCollum (2013) finds a substantial clean-energy investment gap and estimates that achieving the 2°C climate change target requires US$30 trillion, or $0.8 trillion per year, in additional investment flows into low-carbon energy and energy efficiency beyond the current path of planned global emissions-reduction policies.

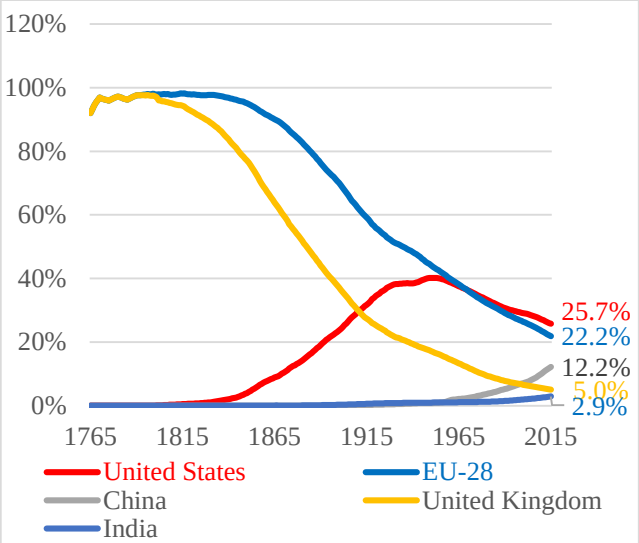
While coordinated global action offers the surest framework for achieving climate targets, debate over the distribution of responsibility has handicapped effective international efforts. US President Donald Trump announced in 2017 that his country would withdraw from the Paris Agreement, citing disproportionately stringent climate targets imposed on the US compared to China's and India's commitments (Chakraborty 2017). China is the world's largest emitter of CO_2 with 28% of the total in 2015, followed by the US with 15%, the EU-28 with 9%, and India with 6% (Figure 5). However, when considering China's export volumes, by using consumption-based measures of emissions instead of production-based measures, the country's emissions levels would be around 20% lower, while those of the US and Europe, as net importers, would be higher. In arguing for less stringent targets, China and India point to their larger populations and to their smaller cumulative contributions to emissions since the industrial revolution. Indeed, emissions per capita reached 16.4 tons in the United States in 2016, 15.4 tons in Canada, and 16.5 tons in Australia, whereas China's emissions were only 7.4 tons per capita and in the low single-digits in almost every country in Africa and South America, according to the Global Carbon Project. Similarly, the United States leads the world in cumulative CO_2 emissions in the period between 1750 and 2016, followed by the EU-28, while China and India lag behind despite their larger populations and acceleration in their emissions over the past three decades (Figure 6).

Figure 5: CO_2 emissions by country, 2015



Source: Carbon Dioxide Information Analysis Center

Figure 6: Share of cumulative CO_2 emissions



Source: Global Carbon Project

Alternative proposals

With very limited exceptions, countries acknowledge that significant damages will result from unchecked growth in man-made GHG emissions, so proposals have focused largely on designing optimal strategies that involve financing mechanisms, policies, or technology to achieve reduction targets. Nordhaus (2015) attributes difficulties in forging international agreements and the failure of the Kyoto Protocol to the free-riding phenomenon. He argues that sanctions against non-participants are necessary for stable coalitions except in the case of limited abatement, and calls for a Climate Club, a regime that uses small trade penalties on non-participants to induce stability in the coalition and high levels of abatement. Metcalfe (2015) proposes that developed countries transfer their allocations of newly-issued IMF SDRs to the Global Climate Fund. He argues that developed economies have minimal need for additional reserve assets to uphold confidence in their currencies because of their floating exchange rate systems, and can thus redirect what he considers to be idle resources to better use in the fight against climate change in low-income countries.

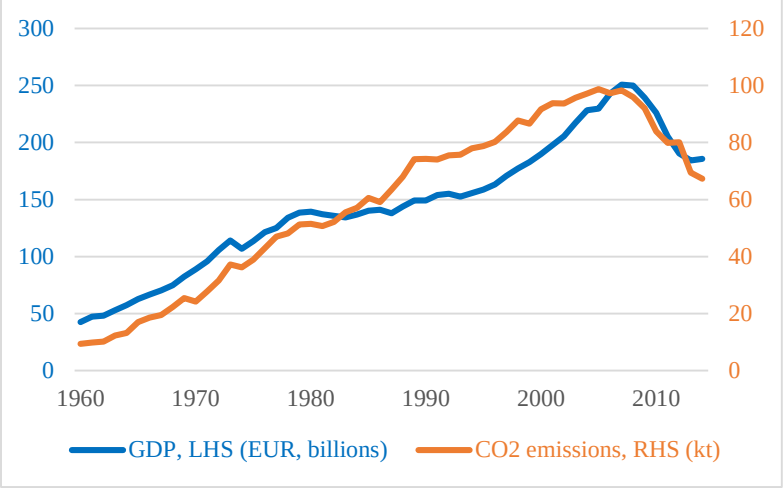
Meanwhile, carbon dioxide removal technology is recognized as a potential long-term meaningful contributor to the response to climate change. EGR (2017) expresses optimism over the potential for breakthroughs from investment in developing carbon removal technology options over time, but notes that many of the approaches remain expensive and have a low level

of technical readiness for global scale deployment. The report finds similar near-term constraints and future potential from the use of direct air capture, the practice of chemical or physical separation of carbon dioxide from ambient air, and from the use of bioenergy with carbon dioxide capture and storage (BECCS).

Although not a policy recommendation by itself, scaling back economic activity has been shown to curb GHG emissions. Greece stands as a recent example of the reductions in emissions resulting from economic collapse; GDP contracted by 26% between 2007 and 2014 after the country was hit by a financial crisis, leading to a decrease of 31.5% in CO_2 emissions over the same period (Figure 7). Other countries, including the United States, exhibited similar trends in emissions in the years following the global financial crisis as production, consumption, and the extraction of resources slowed considerably.

Unlike recessions, which do not appear to spare the output of climate-friendly products and services, the cap-and-trade mechanism uses permits to cap the volume of carbon emissions while relying on the market system to allocate and price them. Businesses with emissions in excess of their permits face tax liabilities, while those with lower emissions trade their surpluses in the marketplace. The European Union's Emissions Trading System is the world's largest carbon market and forms part of the bloc's cap-and-trade policies. Its objective is to ensure that emissions are cut in areas where reduction costs are lowest, and to promote investment in clean, low-carbon technologies.

Figure 7: Greece GDP and CO_2 emissions



Source: World Bank

Hache (2019) argues that carbon markets are characterized by excess allowances and fraud, and face major conceptual issues due to the absence of a price signal. As carbon becomes an asset class, Hache points out that carbon markets, more than traditional markets, can be expected to become more vulnerable to failures and abrupt loss of investor confidence. Instead, he calls for a mandated progressive phasing out of fossil fuels along with targeted tax policies to address climate change. Some environmental groups have also proposed Command and Control (CAC) policies that rely on regulations instead of financial incentives to achieve emissions reductions. Under a CAC system, polluting firms are legally required to reduce their emissions by a certain percentage and may also be required to install pollution-reducing technology. Meanwhile, Dafermos et al. (2018) find that a green quantitative easing (QE) program that increases the price of green corporate bonds can somewhat reduce climate-induced financial instability and restrict global warming, but would require a combination of additional environmental policies, such as carbon taxes, green public investment, green loan subsidies, and regulations, in order to keep the increase in atmospheric temperatures close to 2°C.

Carbon taxes are in fact among the most popular and widely used policies to curb GHG emissions. The policy involves levying a tax on carbon emissions of firms in an amount equivalent to the social cost of carbon, estimated using one of many distinct models, in order to correct the failure of markets to properly price the pollutant. In a January 2019 opinion piece in the Wall Street Journal, thousands of US economists, including several Nobel Laureates and senior policymakers, endorsed carbon taxes as a mechanism to curb climate change, arguing that "by correcting a well-known market failure, a carbon tax will send a powerful price signal that harnesses the invisible hand of the marketplace to steer economic actors towards a low-carbon future" (WSJ 2019). Global Carbon Tax (2019), a Swiss-based NGO, called for the elimination of all GHG emissions by 2035 using a universal, unified carbon tax applied at the points of emissions, starting at US$50 per ton of CO_2e in the first year and rising to US$1,000 per ton of CO_2e by year 15. In order to minimize the impact on consumer prices from the carbon tax, the NGO suggested redistributing half of the funds raised to consumers, 40% for renewable energy infrastructure, and the rest for R&D, climate mitigation, and national support funds.

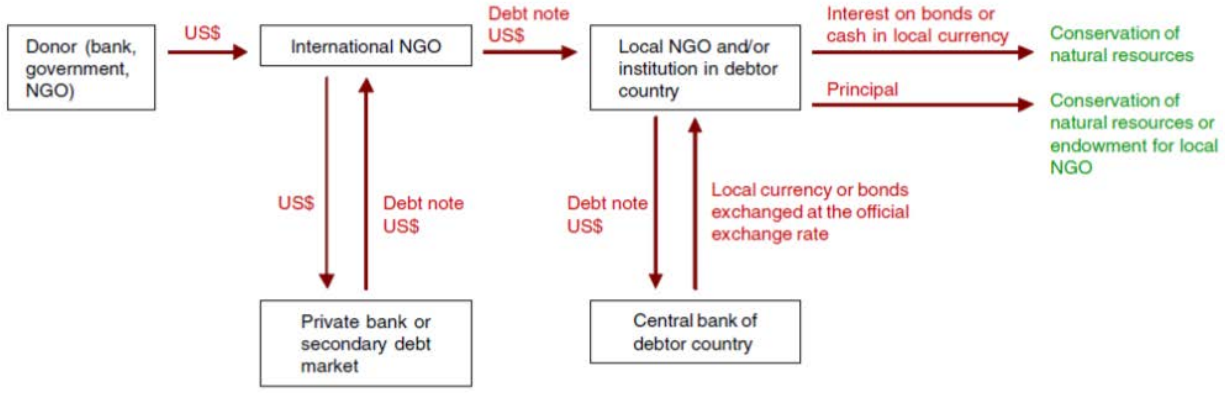
While helpful in generating revenues for social spending, a carbon tax would not be sufficient to transform energy systems, according to Steckel and Jakob (2018). Their study reveals that developing countries will be the source of the largest increase in energy demand in the future, but those countries face a high cost of capital due to higher risk, which impedes flows of large-

scale investments required to finance the transition to renewable energy. They propose policies to de-risk investments in renewable energy in low-income countries, including the development of a stable investment environment, flexible rules for carbon prices, transparent policies, government guarantees, and insurance.

V. DEBT-FOR-NATURE SWAPS

Debt-for-nature swaps (DfNs), an environmental financing mechanism, represents one the most successful cases of external climate aid, and offer significant lessons for the implementation of Structural Environmental Adjustment Plans. DfNs were first proposed in 1984 in the aftermath of the 1982 debt crisis, which had caused the prices of developing countries' sovereign foreign currency bonds to plummet in secondary markets, but it wasn't until 1987 that the first DfN took place. They evolved from debt-for-equity swaps which had gained in popularity around the same time, and involved the acquisition of sovereign debt at a discount in secondary markets followed by their resale to the central bank of the issuing country in return for stakes in local businesses or assets (Korfhage 1990). Korfhage (1990) credits Thomas Lovejoy, then a VP at the World Wildlife Fund in the US, for proposing a similar mechanism that would offer some debt relief to debtor countries in exchange for environmental conservation. DfNs involve the conversion of foreign currency debt acquired at a steep discount in secondary markets by external donors, typically international conservation groups, into local currency debt, which is then donated to domestic environmental non-governmental organizations who use the proceeds, including principal and interest, in the conservation of natural resources (Figure 8).

Figure 8: Principal mechanism for international debt-for-nature swaps



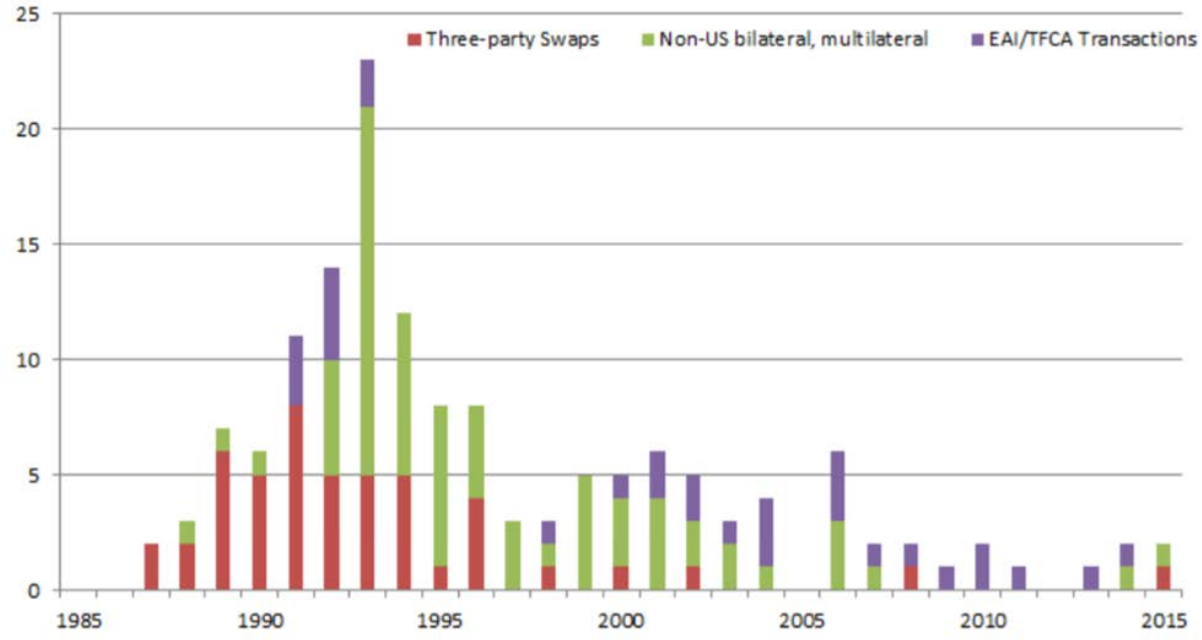
Source: Greiner and Lankester (2007) based on Philp (1992)

DfNs gained considerable international support in the late 1980s and early 1990s and became a popular instrument of debt relief conditional upon environmental conservation. International debt swaps featured in George H.W. Bush's "Enterprise for the Americas Initiative" which aimed at promoting free trade, privatization, and debt relief in Latin America. In 1992, the US

agreed to reduce the burden of its Paris Club-rescheduled debt for several Latin American countries provided they use 40% of the debt relief for environmental restoration projects. Projects included the maintenance and restoration of parks, protected reserves, and natural areas, land management, capacity building for park rangers, development aid for communities within or near tropical forests, and medical research targeting tropical forest plants. European countries were also active participants in DfNs, led by Germany, France, Canada, and Switzerland. Recipients of debt relief under DfNs included Costa Rica, Bolivia, Mexico, Brazil, Chile, Guatemala, Ecuador, Philippines, Nigeria, Madagascar, and Tunisia.

In the two decades through 2003, nearly 30 countries had participated in debt-for-nature swaps generating over $1 billion in funding for environmental conservation (UNDP 2003 in Greiner and Lankester 2007). The US Congressional Research Service estimates that debtor countries received $2.6bn in debt relief through DfNs by 2015, generating $1.2bn in conservation funds (Figure 9). DfN activity faltered in the second half of the 1990s following the introduction of more favorable debt relief programs such as the heavily indebted poor countries (HIPC) initiative, and the conclusion of the Brady Plan. Debtor country foreign currency bonds were no longer trading at steep discounts, reducing the attractiveness of debt acquisition in secondary markets by global NGOs.

Figure 9: Number of debt-for-nature swap transactions



Source: Congressional Research Service

Conservation funds generated through DfNs have been effective at improving environmental outcomes at debtor countries. Korfhage (1990) described the swaps as a success and a necessity for conservation in debt-ridden but environmentally rich countries, calling on international monetary institutions to join governments in using DfNs, especially in Africa where most sovereign debt was held by the IMF and the World Bank themselves at the time. After analyzing 21 transactions, Deacon and Murphy (1997) found that DfNs enhance the enforcement of property rights of government-owned lands and rarely bring about a transfer in ownership. Shandra et al. (2011) find substantial evidence that developing countries that implement DfNs tend to have lower rates of deforestation than similar nations that do not implement these swaps. They also find that higher levels of international NGOs in low-income countries is associated with lower rates of forest loss. Resor (1997) attributes significant gains in conservation and several social programs to the implementation of DfNs, and Knicley (2012) finds a trend of increased participation by indigenous groups under DfNs, but points to variations between swaps in the level of protection of indigenous rights.

While successful, DfNs faced many challenges, most of which understandably emergeing out of the earliest transactions. Deacon and Murphy (1997) point out that “resource conservation” is a vague concept that is open to several interpretations and definitions, thus complicating contract negotiations. In addition, they note that working with the authorities in a sovereign nation involves much uncertainty and potential pitfalls, so projects that do not serve the interests of the government in power do not receive support because of the requirement of negotiating each contract separately with the authorities. Receiving funding also depends on the attractiveness of particular natural resources to international conservation groups, whose priorities may be different from those of local NGOs. Moreover, the case-by-case approach to DfNs and the large number of stakeholders involved leads to a lengthy negotiation and contract preparation process, adding to administrative costs and to risk. Meanwhile, directing the funds to NGOs does not guarantee favorable outcomes are achieved, even if everyone along the process is well-intentioned. Greener (1991) expresses uncertainty over compliance and enforcement of conservation contracts. Deacon and Murphy (1997) argue that the often vast and remote nature of the assets that the swaps seek to protect makes them prohibitively expensive to monitor and to control even by the state. Mateo (1993) warns that DfNs may have an impact on the management of money supply, securities, markets, and interest rates. However, Korfhage (1990) finds that the impact of DfNs on inflation has been minimal, and even at higher rates, the impact

can be minimized through the use of perpetual bonds whereby the principal serves as a permanent endowment for local NGOs. Brazil's government recognized a potential effect on inflation following the approval of its DfNs program, but announced that the government would take measures to minimize the impact, including carrying out the program in successive stages (Geothals 1991). Korfhage (1990) questions the willingness of many developing countries to participate in DfNs given their reluctance to commit to resource management practices dictated by external parties, and the social pressure that might result if the swaps are perceived as land sales to foreigners. One case in point is Brazil where DfNs were widely condemned by civil society and local ecologists who considered DfNs to legitimize the external debt and provide for private botanical gardens where foreign scientists and multinationals have unfettered access to genetic wealth that would later be patented and sold at exorbitant prices (Barreiro 1992). To Philp (1992), DfNs do not address the fundamental development problems facing low-income countries, and their widespread use reduces moral and political pressure for meaningful solutions. Some claim that offering rewards for environmental conservation could induce countries to threaten to degrade their resources to receive funds, but Deacon and Murphy (1997) find no evidence to support such claims in the two-dozen transactions they reviewed.

The popularity of DfNs in the 1980s and 1990s and their success in delivering favorable environmental outcomes represent a valuable building block for the SEDRs climate finance mechanism. The effectiveness of external aid has always represented a key concern for donor countries and development institutions, and those concerns have been magnified by the ramping up of commitments and by the challenges involved in measuring the real environment where the manifestation of effects spans a longer period than most typical project cycles allow. While reporting requirements have grown considerably alongside financing commitments, donors have continued to favor results-based assistance over unconditional aid. Instead of deterring financial aid flows, stringent reporting requirements have given rise to businesses specialized in the development of technology and methods for the measurement of aid effectiveness. Firms often leverage a mixture of spatial analysis, satellite imagery, global geographic information systems, and social media to assess the impacts of projects and policies on the natural environment and economic activity. Those advances, most of which took place after DfN activity had slowed, along with national capacity building, can be reasonably expected to facilitate an effective implementation of the large-scale climate finance initiative envisioned under the SEDRs mechanism. In addition, contrary to the case-by-case nature of DfNs, SEAPs involve a

streamlined, indefinite, long-term financing commitment through the IMF, as well as similar conservation commitments from participating countries. At the same time, the success of SEAPs does not depend on the financial attractiveness nor the availability of discounted foreign currency debt in secondary markets, but on the capacity of the participating country to achieve a range of climate outcomes. In effect, SEDRs financing is akin to DfNs with a 100% discount rate under a comprehensive environmental plan that is significantly less prone to biases in the selection of conservation projects. Sovereignty issues are also mitigated through SEDRs; developed countries have stakes in the preservation of natural resources of developing countries as is the case under DfNs, but emerging and developing countries too have claims over climate outcomes of developed countries participating in the mechanism through self-finance.

VI. THE IMF'S FORGOTTEN RESPONSIBILITY

SEDRs combine concepts from the Internal Monetary Fund's Special Drawing Rights (SDRs) with features from John Maynard Keynes's International Clearing Unit proposal, Nicholas Kaldor's commodity reserve currency proposal, and developing countries' proposed "link" during SDR debates in the 1960s. All four approaches recognize risks to global and national economic objectives from unchecked current account imbalances and from insufficient access to development finance by developing countries, placing all proposed responses within the scope of the IMF. The IMF was born out of the International Monetary and Financial Conference of the United and Associated Nations held at Bretton Woods, New Hampshire in July 1944. It was there that 44 countries signed off on its Articles of Agreement which were largely outlined by Keynes and Harry Dexter White. Signatory countries saw in the establishment of the IMF a formal setting for collaboration on international trade and monetary challenges. It would help avoid repeating the competitive currency devaluations that contributed to the Great Depression and ensure stability in the international monetary and payments systems. The IMF was expected to lend to member countries facing balance-of-payments deficits in order to promote global trade compatible with high levels of income and employment.

Countries agreed at Bretton Woods to establish par values for their currencies against the US dollar, itself tied to gold, and committed to maintain market rates within one percent of that value. Changes to par values required consultation with, and approval of, the Fund, which would not withhold such approval in the cases of a "fundamental disequilibrium" in the balance of payments, a condition that remained constructively vague. Members also agreed to gradually lift restrictions on the convertibility of their currencies to gold and other foreign currencies. In effect, the Fund agreement was similar to a depreciation non-proliferation pact; countries could no longer depreciate their currencies at will to improve their trade competitiveness. Instead, the agreement called for countries to use their own reserves, borrow from the Fund, or use domestic policies to correct payments imbalances that were not deemed to represent a "fundamental disequilibrium."

It is justifiably hard to fully comprehend in the 21st century the scale of the leap in global monetary cooperation that the IMF represented in a world just coming out of two world wars and centuries of colonization. Austin Robinson, a close associate of Keynes, would declare decades later: "What was Bretton Woods about if it was not the creation of a world in which countries did not close their eyes to the repercussions of their actions on others" (Keynes 1975,

19)? The leap, however, carried with it the seeds of recurring crises until the par system finally collapsed in 1973.

Its biggest drawback emanated from the failure to address consistent payments imbalances and the resulting unchecked build-up of large destabilizing reserves by surplus countries. JM Keynes had recommended that surplus countries be penalized to help restore balance, instead of placing the burden of adjustment squarely on deficit countries. He proposed a common unit of account, bancor, that would be used by an international clearing union to record debits and credits emerging from payment flows between member countries. Use of the unit would prevent central banks at surplus countries from hoarding gold and placing the full responsibility of adjustment on deficit countries. Instead, bancor credit balances would be on-lent to deficit countries subject to limits on the size of credit and debit balances and to penalties on countries exceeding them. Kregel (2019) argues that Keynes' clearing union proposal would restore the stabilizing role of capital flows and enable national policymakers to more effectively achieve their objectives:

> "In such a scheme, the debtor/deficit country would never run out of money, since the creditor/surplus country would automatically provide the lending required. In this way, it would be possible for divergent individual country policy objectives to be achieved as long as all countries remained participants in the system—the system as a whole would always have a balance of debits and credits. It would also enable a more balanced adjustment process, since the financial flows would not produce the same immediate impact on domestic financial conditions, and would allow more time for adjustment in real variables such as wages." (Kregel 2019, 7)

Keynes's plan eventually lost to the less ambitious alternative represented by the IMF and World Bank, but attempts to resolve the issues of imbalances through the creation of an international reserve currency persisted, gaining more steam throughout the 1960s after it became clear that gold supply would be insufficient to meet global liquidity needs while reliance on US deficits to supply US dollar reserves to the world would not be a sustainable solution. In a memorandum to the United Nations Conference on Trade and Development in 1963, Nicholas Kaldor, Albert Hart and Jan Tinbergen proposed the creation of an international commodity reserve currency, building on earlier works by Benjamin Graham (1937), Jan Goudriaan (1932), and Alfred Marshall's sym-metallic standard (Hart 1976). Unlike Keynes's bancor, which required no buffer stocks to restore balance, Kaldor's currency reserve unit

involved fixing the price of a basket of commodities containing actual physical amounts of standardized, durable-in-storage primary commodities. If the market price of the commodity basket breached a pre-defined price band, the IMF (presumed to be operating the scheme) would intervene in the market by buying or selling commodity-baskets from its buffer stock so as to restore market prices back to levels consistent with the commodity-basket's fixed price. Commodities proposed for inclusion in the buffer stock included wheat, maize, iron, coffee, cotton, copper, and more than a dozen others. Carbon credits have also since been proposed for inclusion in the basket. Kaldor's plan aimed at reestablishing a relationship between monetary values and real magnitudes, thereby stabilizing inflation through direct intervention in basic commodity prices, particularly in years with unusual agricultural output. It would promote steady economic growth in developing countries by safeguarding incomes of primary producers (Hart 1976).

In response, Grubel (1965), citing Friedman (1951), argued that a commodity reserve currency would itself be a source of price instability due to the large volume of buffer stocks and their disproportionate growth relative to commodities output. At the same time, the accumulation of stocks offers no advantage over fiat money, while the burden would be no different from that involved in gold reserve holdings: "Men toil to dig the metal out of the ground and other men rebury it. The Hart-Kaldor-Tinbergen plan advocates increasing manifold the resources devoted to this folly" (Grubel 1965, 133).

Instead, the IMF adopted a proposal for the creation of Special Drawing Rights (SDRs) born out of the Ossola Group in 1964-1965 which was tasked with examining the various proposals for the creation of reserve assets. The US took the lead in developing this concept for deliberate reserve creation, but balked at the idea of granting the IMF the right to issue drawing rights at its own initiative, especially if those rights are transferable directly between countries, mainly for fear that they would represent a direct substitute for the US dollar (Solomon 1977). Robert Solomon, himself a member of the Ossola Group, described the SDR as "a symbol of the move toward international monetary integration, toward more symmetrical international monetary system, and toward the eventual conversion of the IMF into a world central bank" (Solomon 1977, 335).

The path to the launch of SDRs, however, was difficult, with France starting out as a fierce critic, calling instead for a strict gold-based system of international reserves. The country proposed in 1964 the creation of a new reserve asset, the "Collective Reserve Unit" that would

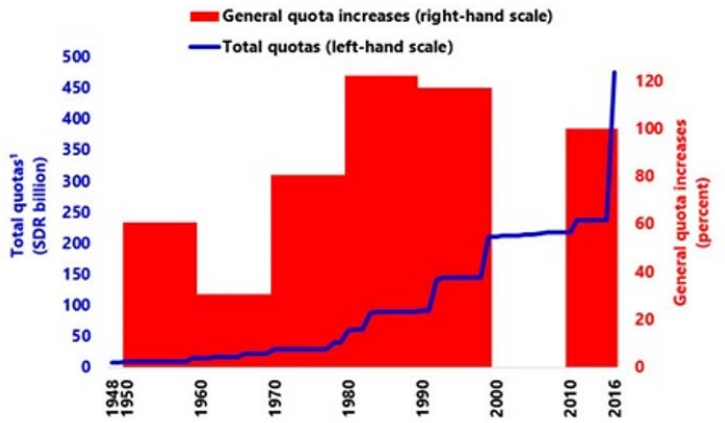
derive its value from gold and would be issued and used outside the IMF by an exclusive group of advanced economies. Meanwhile, emerging markets sought competitive access to advanced markets and to development aid, which had declined sharply as a result of monetary crises in the second half of the 1960s and which would intensify in the early 1970s. As likely net users of SDRs, they fought tooth and nail to earn their right to participate (Williamson 1977). At the same time, emerging markets preferred to maintain the freedom to choose the composition of their reserves instead of shifting all reserves to SDRs as one proposal stipulated. Unlike France, the US argued for an IMF mechanism that includes emerging markets. In practice, the US advocated and significantly popularized the use of currency swap lines between central banks to meet liquidity needs under the par value system.

The SDR is now the IMF's official unit of account and an international reserve asset that serves as a means of payment among Fund members that are participants in the IMF's SDR Department, including the Fund itself and other prescribed holders such as multilateral funds (Treasury Department 1995). SDRs can be deliberately created by a decision of the Fund and allocated to member countries who would use them to supplement their existing reserve assets. The first allocation took effect at the start of 1970. After the collapse of the par exchange rate system agreed in Bretton Woods, and the floating of most developed countries' currencies, SDRs gained more significance. As a result, the Fund's Articles of Agreement (AoA) were amended in 1978 with the aim of considerably enhancing the role of SDRs and requiring members to "collaborate with the Fund and with each other to make the SDR the principal reserve asset in the international monetary system[2]" (Ibid., 1). SDRs are a potential claim on the holdings of freely usable currencies of participants in the SDR Department, which in effect includes all IMF members (IMF 2018). The IMF conducts five-year reviews to determine which currencies are freely usable by evaluating if they are widely used to make payments for international transactions and widely traded in principal exchange markets. As of the latest IMF review in 2015, the SDR basket of currencies includes the US dollar with a weight of 41.73%, the Euro with 30.93%, the Chinese Yuan with 10.92%, the Japanese Yen with 8.33%, and the Pound Sterling with 8.09%.

[2] The Second Amendment, which entered into force on April 1, 1978, established the rights of members to adopt exchange rate arrangements of their choice, offered attractive yields on SDRs, and widened their scope of use.

The allocation of SDRs is subject to country quotas which are determined by the size of each economy, its openness to trade, economic variability, and reserve holdings. Quotas represent an asset and a liability, such that any decline below the quota subjects the member country to interest, and any excess holdings earns it interest. Countries may use their own currencies to meet up to 75% of their quota subscriptions, while the rest is required to be filled in SDRs or any of the five freely usable foreign currencies: US Dollar, Euro, British Sterling, Japanese Yen, and Chinese Renminbi. SDR holders may choose to exchange them through a transaction by agreement for any of the dozens of currencies for which the Fund has established a representative rate (Treasury Department 1995). Participants enjoy the freedom of buying and selling SDRs both spot and forward, borrowing, lending, and pledging them, and even using them in swaps or donations. Obstfeld (2011, 3) emphasizes that the SDR is not a currency and does not create new liquidity, but functions "largely as a reserve-pooling arrangement, useful in re-allocating liquidity from countries with ample liquidity to those with higher needs." Participant countries are obligated to provide currency, upon request from the IMF, of no more than two times more than their net cumulative allocations, but the aggregate volume of SDRs is limited by total available allocations, thus capping total finance that deficit countries can access under the scheme. Despite the limited size of SDRs relative to global reserves, the transactions process serves to recycle some liquidity from surplus countries to those in need. The process involves either voluntary exchange between a buyer and a seller of SDRs to obtain hard currency, or a designated exchange - "in designation" - through which the IMF calls upon a surplus country to acquire SDRs from a deficit country. In practice, use of SDRs "in designation" has not taken place since September 1987, but its existence ensures that deficit countries holding SDRs are able to unconditionally obtain currency when the need arises. To achieve that objective, Fund staff draw up on a quarterly basis a list of participants with strong balance of payments and reserve positions that they can call upon to provide freely usable currencies if the need arises. Access to finance through SDRs for the purpose of changing the composition of reserves is prohibited, with the use only assessed by the IMF ex-post to ascertain the requirement of need was met: "A participant will be expected to use its special drawing rights only if it has a need because of its balance of payments or its reserve position or developments in its reserves" (Ibid., 47). IMF members have often resorted to issuing new SDR allocations when faced with global economic crises, including in response to the global financial crisis of 2009 through a general allocation of SDR161.2 billion (US$250 billion) (Figure 10).

Figure 10: IMF quotas



Note: Total quotas also include new members and ad hoc increases.
Source: IMF, Finance Department statistics

In addition to quotas, the IMF has used special facilities to respond to swings in commodity prices that could destabilize payments balances for importers. For example, following a surge in crude oil prices in 1974, the Fund established a special facility, dubbed the "oil facility," offering loans to oil-importing countries to smooth their adjustment process. The Fund reached borrowing agreements with oil-exporters including Abu Dhabi, Iran, Kuwait, Libya, Oman, Saudi Arabia, Venezuela, and Canada. The facility made around SDR 6.9 billion in assistance available by May 1976, equivalent to 74% of SDR allocations at the time, to members demonstrating a balance of payments need resulting from increases in the cost of petroleum product imports. In 1975, the Fund went even further in its response, setting up a subsidy account to cover interest rates of around 7% at the times. A few years later, in 1981, the IMF responded to rising food prices by approving a four-year financing facility to assist members that encountered "a balance of payments difficulty produced by an excess in the cost of their cereal imports largely attributed to factors beyond a member's control" (IMF 1981, 81). The IMF justified its support by pointing to the high caloric content of cereals, wheat, rice, and coarse grains, such as maize, barley, sorghum, and millet as a proportion of food imports of low-income countries.

While the IMF, through SDRs and special facilities, has played an advanced role in responding to imbalances, its role has remained modest in comparison to the challenges to financial and monetary stability in developing countries. One proposal in particular, the "link," had aimed to tie the creation of the SDRs to development finance requirements, but faced stiff opposition

from developed countries. Developing countries saw in the creation of SDRs in the late 1960s an opportunity to increase development assistance from developed countries, so they devised an elaborate proposal, supported by over 100 members, stipulating the allocation of a greater proportion of SDR allocations to developing countries than their quota would have indicated, and an even greater proportion to the least developed countries (Williamson 1977).

Opponents put forward several arguments, but their main objection was that linking SDR allocations to the financing of economic development could undermine confidence in the new reserve asset and thereby impede efforts to convince central banks to shift away from gold. Johnson (1972, 113-114) termed the "link" debates "specious arguments cast in an obsolete intellectual framework whose purpose is to try to obtain by chicanery and deceit what cannot be obtained by honest argument or moral protest…" He insisted that the link proposal was intended to give less developed countries "a political sop preposterous enough to be rejected by the developed countries, yet plausible enough to be accepted by the less developed countries as a legitimate grievance against injustice." He added:

> "It is unfortunate, in my judgment, that the less developed countries have chosen, and particularly that UNCTAD has chosen, to put so much weight on the link proposal as the way ahead in development assistance, and to support that proposal with obsolete arguments derived from the 1930's which assume that capitalism is in chronic risk of mass depression and unemployment unless rescued by pump-priming investments in pyramid-building and that the gold standard still prevails in its pre-World War I form." Johnson (1972, 116-117)

While the "link" proposal appears unlikely to be resurrected, other ideas have continued to find their way back into economic and policy debate. In particular, Zhou (2009, 3) attempted to resurrect the concept of a substitution account by calling for an open-ended SDR-denominated fund that would allow "subscription and redemption in the existing reserve currencies by various investors as desired," likely in a bid to mitigate currency risk in China's predominantly US dollar reserves.

Despite their shortcomings and limited reach, the IMF and the SDRs enjoy unanimous international membership and have played a role in virtually every national and international payments crisis since their establishment. The challenges presented by climate adaptation requirements to the balances of payments of developing countries are monumental, and call for an equally powerful response from the IMF. The overwhelming majority of new coal-powered

plants are expected to be built in developing countries such as China, India, Turkey, Indonesia, Vietnam, Pakistan, and Egypt, most of whom suffer from large payments deficits and rising external debt risk, compounding their climate adaptation challenges in the absence of sizeable foreign support to secure renewable energy needs and mitigate the impact on their payments balances (Appendix, Figure 20).

Climate change is therefore a responsibility that the IMF has so far elected to ignore, even as it has in the past recognized the impact on payments balances from high fossil fuel prices or high prices of primary food commodities. This paper proposes a SEDRs financing mechanism designed primarily to supply liquidity to countries seeking to invest in the transition to renewable energy and environmental conservation. Instead of wasting commodities in a Kaldorian commodity reserve, SEDRs require that each participating country maintain or improve its level of environmental reserve assets such that any surpluses in those reserve assets yield positive returns to the whole world.

VII. A PROPOSAL FOR SPECIAL ENVIRONMENTAL DRAWING RIGHTS

A. Background

The effects of climate change on global output are contractionary and widespread. Burke, Davis, and Diffenbaugh (2018) find there is a more than 75% chance that global economic damages would be lower through 2100 if global warming was limited to 1.5°C relative to 2°C, and a more than 60% chance that the accumulated global benefits[3] would exceed US$20 trillion at 2010 prices under a 3% discount rate. They also find that an estimated 90% of the world's population and 71% of countries have a more than 75% chance of experiencing reduced economic damages at 1.5°C relative to 2°C. Beyond 2°C, the size of incremental damages is disproportionally higher, suggesting considerable risk to global output from missing climate targets, particularly when taking into account unprecedented extreme outcomes, such as large-scale sea level rise, that are difficult to predict because the world may only experience them at higher temperatures.

The global nature of the planet's warming and the size of potential gains from achieving climate targets[4] call for a global response. The challenge is immense for high-income and low-income countries alike, but any meaningful response by the majority of developing countries and for many middle-income countries will be disruptive to their balance of payments. For example, capital costs associated with renewable energy systems are disproportionately greater than those of fossil fuel plants, while the latter's operating and maintenance (O&M) costs are considerably higher both financially and socially. At the same time, the technology and manufactured inputs used in renewable energy plants, such as solar panels, wind turbines, and storage batteries, are sourced from a small number of exporting countries, ensuring that any meaningful transition to clean energy requires a scale up of imports along with the associated build-up of foreign currency debt or depletion of any foreign currency reserves. Nine countries alone contributed to more than 90% of photovoltaic cells exports in 2017[5], and only nine countries, led by China, reported a surplus in photovoltaic cells trade in 2017, whereas 131 countries, led by the United States, reported a deficit, reflecting the breadth of the global challenge to payments balances presented by the transition to renewable energy, particularly in developing countries.

[3] Defined by the authors as the value of avoided impact.
[4] Signatories to the UN Paris Agreement pledged to hold global temperatures at "well below 2 °C above pre-industrial levels" by 2100 and to pursue a 1.5 °C target.
[5] Based on data as of March 12, 2019 from the United Nations International Trade Statistics Database (UN Comtrade).

The transition to renewable energy alone would go a long way in achieving the 2030 interim target of reducing annual greenhouse gas emissions to a range of 22-30 $GtCO_2e$, the level consistent with the objective of limiting the global temperature increase from the pre-industrial revolution period to below 1.5°C by 2100 with about a 66% chance (UNEP 2017). A United Nations Environmental Programme (UNEP) report published in 2017 estimates that carbon taxes of less than US$100/$tCO_2e$ would result in annual emissions reductions ranging between 35 $GtCO_2e$ and 41 $GtCO_2e$ in 2030, sufficient to close the emissions gap. The report focuses on socio-economic potential by targeting reductions that can be achieved with all technologies available using social, not private, payback times. In the energy sector alone, solar, wind, and hydro power could result in emissions reductions between 5.9 $GtCO_2e$ and 10.4 $GtCO_2e$, contributing to up to 36% of the reductions required by 2030.

UNEP (2017) pointed to massive potential reductions that would be accrued from avoiding the construction of new coal-fired power plants and from phasing out existing ones. If new and existing coal-power plants were operated under the current status[6], they would be expected to emit an estimated 332 $GtCO_2e$, 55% of the carbon emissions budget consistent with a climate target of below 1.5°C. The overwhelming majority of new coal-powered plants are expected to be built in developing countries such as China, India, Turkey, Indonesia, Vietnam, Pakistan, and Egypt, most of whom suffer from large payments deficits and rising external debt risk, compounding their climate adaptation challenges in the absence of sizeable foreign support to secure renewable energy needs and mitigate the impact on their payments balances.

The complex nature of the challenge in developing countries shows the limits of carbon taxation as the primary mitigation policy. Steckel (2018) argues that when capital costs are high, carbon pricing is likely to be insufficient in raising the shares of renewable energy sources in the energy sector, and calls for complementary measures to decrease investors' capital costs. McCollum et al. (2013) argue that a considerable upscaling of investments into low-carbon energy and energy efficiency is required to reach climate targets. He finds that an annual clean-energy investment gap of US$800 billion between 2010 and 2050 is consistent with a 2°C climate change target, a cumulative investment requirement of US$10-55 trillion beyond what investments might otherwise be under present and planned emissions-reducing policies throughout the world. The gap consistent with a 1.5°C target is more than 50% larger (McCollum et al. 2018).

[6] Assumes a lifetime of 40 years for power plants and no retrofitting with carbon capture and storage.

This paper proposes a global financial mechanism that leverages each country's environmental assets to deploy all the capital, technology, and know-how required to meet the 2100 climate change targets and preserve any gains for future years. The mechanism aims to replicate the role that Special Drawing Rights have played in improving liquidity and facilitating global economic growth and trade in the battle against climate change. The claims' acceptance by all members of the IMF as a tool for liquidity creation in cases of payments and global economic crises is perhaps one of the few remaining accomplishments of global monetary cooperation in the post-World War II period. Successive increases in SDR general and special allocations since the 1960s testify to international confidence in the effectiveness of the reserve asset, even when conservatively deployed, in mitigating the risk of global depressions and payments crises.

B. Process

The proposed climate financing mechanism through Special Environmental Drawing Rights (SEDRs) builds on two decades of experience in debt-for-nature swaps, five decades of global recognition of the SDRs' role in promoting global liquidity, and reserve asset reforms proposed prior to the collapse of the Bretton Woods system in 1973. SEDRs serve as a unit of account for a country's environmental reserve assets (ERAs) and related activities, with each SEDR equal to the value of one SDR. SEDRs give countries the right to an equivalent interest-free, 20-year loan from the IMF and the right to offset the loan using environmental outcomes.

The process of earning SEDRs (Figure 11) begins after a country expresses interest in borrowing from the Fund or in using its own financial resources in order to maintain and improve its natural assets (the natural base). For countries seeking financing from the IMF, borrowing capacity is only limited by their ability to achieve a set of environmental targets over the following 20-year period. The expression of interest is followed by the design of a structural environmental adjustment plan (SEAP) involving the calculation of its SEDR stock by developing a detailed description of its ERAs along with a plan with investment requirements to achieve a set of targets for the reduction of GHG emissions, waste, and freshwater abstraction, expansion of forest and protected areas, and recovery of endangered species. Any participation in the SEAP requires, by default, a commitment to a floor for all components of a country's ERAs, even if no action involving those components is being undertaken. After the adjustment program and commitments are prepared, the IMF and the participating country negotiate the

SEDR accrual schedule; if the country is drawing on Fund resources for its program, the accrual matches the amortization of the debt such that any loans are gradually offset by a proportional growth in accrued ERAs over the 20-year period. The accrual of SEDRs and the actual amortization of the loan are subject to annual local and international monitoring, evaluation, review, and verification.

Figure 11: The SEDRs accrual process

Source: Author's illustration

SEDRs operate in some respect like the SDRs "in designation" format. They can only be issued subject to environmental need or investment, but borrowing from the Fund to finance environmental investment is conditional upon a demonstrated financing gap. Countries with strong payments balances would be among the first to be designated to supply funds to the IMF for the SEAPs. As a result, the SEDRs mechanism requires an unlimited and indefinite commitment by all member countries to supply funds to the IMF to finance the SEAPs and honor SEDRs obligations.

Countries that are designated by the IMF to supply their currencies receive a note for the same amount, serving as a potential claim, in the same amount and currency, on the rest of the participants in the SEDRs mechanism. The note can only be fully or partially offset if the program is liquidated or if a participating country accrues a liability by withdrawing from a SEAP or failing to meet its terms. Notes have no maturity, mirroring the participant countries' perpetual obligation to maintain the environmental status they achieved through IMF funding. The mechanism's liquidation, which would be designed to prohibit a handful of creditor countries from dismantling it, would leave the countries that participated in SEAPs with a joint liability to the countries that supplied their currencies to the IMF to fund the SEAPs, but they would simultaneously be relieved of related environmental obligations. Countries that self-finance their SEDRs accrual would not be liable in the event that the program is liquidated, but they are still subject to charges and penalties if their commitments are not met while the global program remains in place.

C. The Structural Environmental Adjustment Program

The majority of IMF member countries suffer from environmental imbalances; human economic activities over the past two and half centuries have brought immense degradation of mankind's natural ecosystem through large-scale deforestation, unsustainable extraction of non-renewable natural resources, depletion of underground water reservoirs, and destruction of natural habitats. Global ecological macroeconomic models point to severe long-term economic damages caused by environmental changes, particularly global warming (Bovari, Giraud, and Mc Isaac 2018). Structural Environmental Adjustment Plans (SEAPs) are designed to restore balance to a country's natural ecosystem by reversing losses in forests areas, flora and fauna, and endangered species among others, and by cutting back carbon and other greenhouse gas emissions and the production of hazardous waste. To a large extent, they mirror the format of the IMF's commonly-used Structural Adjustment Plans, but cover exclusively projects and policies aimed at stabilizing and restructuring a country's environmental assets and improving their resilience to natural disasters. SEAPs involve the measurement and consolidation of a country's natural resource base along with specific environmental 20-year targets.

Targets are constructed based on lists of projects and policies prepared in collaboration between a national government and the IMF. They represent a range of feasible outcomes for a set of environmental measures contingent upon the availability of financing. Most countries already have some relevant experience preparing climate-related targets, particularly in relation to reductions in greenhouse gas emissions: parties to the United Nations Framework Convention on Climate Change held in Paris in 2015 (the Paris Agreement) pledged to set national targets for carbon emissions and to provide regular reports on their emissions and on their implementation efforts. Although humble, reporting requirements under the Paris Agreement help set the stage for a more advanced measurement of actual and potential environmental reserve assets in any country seeking to accrue SEDRs by borrowing from the IMF or by using its own resources.

A typical SEAP measures ERAs, including forest areas, GHG emissions, marine and terrestrial protected areas, populations of endangered species, volumes of freshwater abstracted and non-recycled hazardous waste produced. It describes a roadmap to maintain or improve the natural base over the following 5, 10, 15, and 20 years, along with detailed cost estimates associated with the implementation of climate adaptation and transition projects. It also provides a complete regulatory and implementation strategy to achieve climate objectives.

An adjustment plan could entail employment and capital investment to implement large-scale reforestation and afforestation projects, protection and recovery of endangered species, and emissions reductions. Environmental projects require a diversity of professional and technical skills given the breadth of activities involved, such as consulting and capacity building, research and development, energy demand and network planning, tree planting, irrigation, fencing, monitoring of endangered species, veterinary services, retrofitting buildings, engineering, recycling, waste collection and management, installation and maintenance of solar panels and wind turbines, construction of new power lines, and others.

The use of fossil fuels for energy production is the single largest source of global greenhouse gas emissions (IPCC 2014). As a result, SEAPs will almost always include a strategy to reduce emissions resulting from electricity production and heating, but also from the use of fossil fuels to power the industrial sector and both residential and commercial buildings. Moreover, emissions reduction plans would provide policies and an implementation mechanism to reduce the transportation sector's contributions to emissions. Reducing emissions would involve a combination of supply-side and demand-side management starting with the decommissioning of coal, oil, natural gas, and nuclear power plants and replace their supply with renewable energy from wind and solar farms, and small-scale run-of-river hydroelectric power plants that do not require the construction of large dams. New power plants will inevitably require investment in new transmission networks and storage facilities. Considerable reductions in energy emissions would come from demand-side management involving the retrofitting of buildings with energy-efficient insulation, roofing, and windows, and the leveraging of smart home technology, starting with motion sensors, to cut waste. Depending on their size and urbanization rates, countries could seek to get homes off the grid by expanding the use of solar home systems, especially in rural areas.

Participating countries retain the freedom to determine their preferred mechanism for achieving emissions reductions. Those could entail a combination of regulations and incentives for energy efficiency targeting new construction. A country may wish to extend tax credits or offer favorable tariff rates aimed at reducing or even eliminating the use of inefficient appliances such as air conditioning units at both residential and commercial buildings. In the industrial sector, a country may design a mix of environmental standards and tax or interest incentives to help businesses transition way from diesel engines and into solar or wind. National plans give

authorities significant leeway to design their approach which may include carbon taxation and mandatory renewable energy portfolio standards.

Calculating SEDRs

SEDRs are calculated using a combination of environmental and related economic statistics for each country, and are weighted using a method similar to the calculation of IMF SDR quotas. Much like SDRs, SEDRs are a potential claim on the IMF's freely usable currencies, but unlike SDRs, they are defined by each country's natural resources and potential contribution to global climate objectives and the requirements of environmental preservation. Unlike quotas, which are determined by the size of a country's economy and its relative position in the global economy, ERAs are determined by a country's stock of natural resources and feasible potential, reflecting investment requirements for the preservation of existing natural resources and the reduction of negative outcomes, regardless of the relative size of those resources in the world. As such, the capacity to leverage ERAs to access environmental debt financing is limited only by the capacity to repay through favorable climate outcomes over the life of the loan.

Three types of ERAs can be identified: actual ERAs, potential ERAs, and accrued ERAs. Actual ERAs describe existing natural resources at the onset of the first SEAP, such as forest areas, threatened species, marine and terrestrial protected areas, freshwater resources, and levels of hazardous waste and GHG emissions, all of which require continuous investment in capital and labor to preserve or maintain. Actual ERAs are only used in the first SEAP, after which they become part of potential and/or accrued ERAs. Meanwhile, potential ERAs represent feasible increases in natural resources as well as feasible reductions in undesirable outcomes of economic activity, such as emissions of carbon, nitrogen oxides, sulfur dioxide, output of non-recycled hazardous waste, and untreated wastewater generation. The list of undesirable outcomes is bound to increase over time as human history is testament to mankind's vast capacity to innovate, particularly in response to regulatory constraints. Achieving reductions in undesirable outcomes requires significant investment, much of it upfront, and thus raises the limit on the maximum financing available by incorporating them into current levels of ERAs. Accrued ERAs are the real improvements in a country's environmental outcomes, growing by the same amount as the reductions in potential ERAs, but only becoming fully vested at the end of the related 20-year SEAP. A country's environmental improvements relative to the rest of world may also add to its accrued ERAs because they indicate the adoption of more advanced

techniques or policies to produce more favorable outcomes. Relative performance, however, offers an excess addition to accrued ERAs 20 years after the adoption of any given SEAP, but does not contribute to the amortization of any debt during the 20-year period.

Activities related to ERAs include the net trading position in climate adaptation goods and services such as photovoltaic cells, wind turbines, storage batteries, and capacity building. Trade levels indicate the degree to which a country is involved in total flows of environmentally-enhancing goods and services as an importer and exporter, both of which are necessary for the achievement of global climate objectives. A trade deficit increases the size of a country's SEDRs because it indicates a transition to climate-friendly techniques, and therefore greater demand for currencies other than that issued by the sovereign. On the other hand, a trade surplus suggests a sharing of climate-friendly techniques that may have been financed domestically or through international finance. The netting process eliminates the possibility of countries increasing their SEDRs by opting to intermediate in climate-friendly goods and services without creating any value added to the industry. Moreover, the variability of imports of adaptation goods and services accounts for swings in a country's uses of foreign resources to meet environmental challenges, and thus allows for greater access to finance with a weight of 10% for countries that have witnessed more payments gyrations.

International reserves, such as holdings of SDRs and other reserve assets,[7] but not including SEDRs, also factor into the calculation of total SEDRs with a small weight of 5%. Countries holding large reserves will either have large foreign liquidity requirements, or will have a conservative foreign currency posture dictated by their exchange rate policies. In both cases, their foreign reserve management implies a greater preference for foreign currency liquidity. Issuing more SEDRs to countries with greater reserve holdings ensures that environmental policies do not disrupt existing preferences through the likely increase in environmental economic output and trade flows. The downside to including international reserves is that countries with the capacity to finance climate-friendly investments have greater access, all else equal, to borrowing rights, albeit only marginally. This disadvantage is mitigated by the losses accrued from not investing at least a portion of those reserves in the creation of other more

[7] The IMF's sixth edition of the Balance of Payments and International Investment Position Manual (BPM6) defines reserve assets as "those external assets that are readily available to and controlled by monetary authorities for meeting balance of payments financing needs, for intervention in exchange markets to affect the currency exchange rate, and for other related purposes such as maintaining confidence in the currency and the economy, and serving as a basis for foreign borrowing." For further description, see IMF (2015)

highly-weighted types of environmental reserve assets, such as reductions in emissions and expansion of forest areas. As a result, the largest holders of international reserves would be expected to diversify their portfolios away from the limited number and size of international reserve options currently available and into an IMF-issued climate-based asset class whose growth is limited by factors that each one of those countries can influence directly.

Although the IMF's current SDR quotas formula includes holdings of SDRs in the international reserves component, accrued SEDRs are excluded from international reserves in the calculation of current levels of SEDRs. The rest of the SDR quota components are flow measures of economic output, trade, and variability, so accounting for the existing stock of SDRs is necessary to describe a country's international reserve position. In the case of SEDRs, however, ERAs, a stock measure, already present a clear and encompassing summary of a country's natural assets, so the international reserves component only needs to add other types of reserves such as gold holdings, foreign currencies, and other instruments readily available for use by monetary authorities. Furthermore, unlike SDRs which can be traded between IMF member countries and designated entities, accrued SEDRs grant only the country that earned them the right to 20-year interest free environmental loans from the IMF with the maximum amount determined by the SEDRs equation. SEDRs are only accrued after a 20-year SEAP has been completed, so countries that have fully accrued their ERAs will be able to again access the same amount of funds, assuming related economic factors remained the same, for the maintenance of their environmental status.

As a result, a country's SEDRs can be calculated as a linear combination of environmental measures, plus a combination of economic factors, using the following equation:

Total SEDRs = actual ERAs + potential ERAs + accrued ERAs + related economic activities

$$= \mathbf{W}_t^{ia}\mathbf{Cf}_t^{ia}\mathbf{E}_t^{ia} + \mathbf{W}_t^{ip}\mathbf{Cf}_t^{ip}\mathbf{E}_t^{ip} + \sum_{t=1}^{t} \boldsymbol{G_t}(\mathbf{W}_{t-1}^{ip}\mathbf{Cf}_{t-1}^{ip}\mathbf{E}_{t-1}^{ip}) + 15\% * \mathrm{Cf}_t^8\mathrm{NT} + 10\% * \mathrm{Cf}_t^9\mathrm{V} + 5\% * \mathrm{Cf}_t^{10}\mathrm{R}$$

Where:

$\mathbf{W}_t^{ia}, \mathbf{W}_t^{ip}$ = vectors of weight factors for each actual "a" and potential "p" environmental measure "i" at time "t". Weights reflect the relative importance of each component and are used in the dot products of the SEDRs equation. Actual ERAs are only used at the start of the SEAP, so their weights become 0 in later periods.

$\mathbf{Cf}_t^i$ = vector of country-specific conversion factors reflecting cross-country differences in the costs of maintaining each different natural asset and of achieving feasible potential outcomes. Conversion factors are updated once every 20 years, such that "t" refers to a 20-year time period and "i" to each specific ERA component. Conversion factors are the same for both actual and potential ERAs.

$\mathbf{E}_t^{ia}, \mathbf{E}_t^{ip}$ = vectors of actual and potential environmental measures at time "t", such as forest areas, endangered species, protected areas, reductions in GHGs,[8] reductions in hazardous wastes, and relative GHG reductions[9]. Relative reductions are assumed to be in line with global trends until 20 (i.e. excess reductions are zero), at which point, countries with excess reductions will have accrued additional ERAs. The weights for each component are determined by potential contributions to global climate objectives as follows:

Figure 12: Components of ERAs and their relative weights in the first period (t=0)[10]

Environmental Reserve Assets	Unit	Cf	Actual[11]	Potential	Total
Natural base					
Forest area	Km^2	Cf_0^1	1%	2%	3%
Greenhouse gas emissions	Mtons of CO_2e	Cf_0^2	0%	55%	55%
Marine/terrestrial protected areas	Km^2	Cf_0^3	1%	2%	3%
Endangered species	Numbers	Cf_0^4	1%	2%	3%
Freshwater abstracted	Mm^3	Cf_0^5	0%	2%	2%
Non-recycled hazardous waste	Tons	Cf_0^6	0%	2%	2%
GHG reductions relative to trend[12]	Mtons of CO_2e	Cf_0^7	0%	2%	2%
Total			3%	67%	70%

Source: Author's calculations

[8] Reductions are relative to the country's program joining date, i.e. t=0.
[9] Measured starting t=1 or year 20, relative to the rest of the world. May also incorporate reductions in hazardous waste relative to the global trend.
[10] Weights do not reflect the final contribution of each environmental measure to total SDRs due to differences between actual and potential assets.
[11] Actual ERAs are only used at the start of the first SEAP, after which they become part of either potential ERAs or accrued ERAs.
[12] The volume of excess reductions relative to the global trend. This can be calculated as x*(g-n) where "x" is the starting level of emissions, "g" the global rate of change in emissions, and "n" the national rate of decrease in emissions. If a country's emissions increase, the excess is automatically set to zero even if global emissions increased at a faster pace.

G_t = percentage of targets that have been achieved, i.e. proportion of prior potential ERAs identified under each previous SEAP that have been accrued by time "t". This ranges between 0% and 100%, the latter representing full accrual of potential ERAs when SEAPs are implemented and all predicted real outcomes have materialized.

$\mathbf{Cf}_t^{8,9,10}$ = scalar factors common to all countries used to convert currency and standard deviation units into SEDR units. They may be updated no more than once every 20 years, and only marginally, to reflect any structural changes in global trade and finance that affects a country's capacity to leverage its ERAs.

NT = openness to climate-related goods and services, calculated in millions of local currency units as the net of the annual averages of climate-related current payments and receipts during the prior five-year period.

V = variability of imports of climate-adaptation goods and services measured as the standard deviation of imports over the prior five-year period.

R = international reserves, measured as the twelve-month average of official reserves, excluding any SEDR holdings, during the prior year.

Actual ERAs are only calculated in the first period when a country joins the program. After that, only potential ERAs, accrued ERAs, and economic indicators remain in use, with their weight factors summing up to 97%.[13] The country's accrued ERAs, representing achievements towards climate targets since the program joining date, along with a combination of economic factors, enable indefinite access to 20-year, interest-free loans used in the maintenance of the then-current environmental status.

D. ERA commitments

SEDRs offer voluntary access to the IMF's freely usable currencies conditional only upon their use for environmental preservation. They transform trade competitiveness from a race to a climate bottom, evidenced by the global environmental degradation associated with income growth over the past 250 years, to a race above a desirable climate bottom declared by each country, and in some cases, a race to a climate top. As a result, environmental reserve indicators become natural measures of sustainability and investment needs. ERA commitments are similar

[13] The total of 100% minus the 3% allocated to actual ERAs in the first period.

to the IMF's quotas in that they represent both a liability and an asset for the countries declaring them. Once natural assets are committed, their conditions become an asset and a liability to all members of the IMF. For example, a country committing its forest areas receives indefinite access to IMF financing for their preservation. When forest areas are expanded under a SEAP, those new areas raise a country's maximum access to IMF finance and its maximum liability from a contraction in those areas. If committed, reductions in GHG emissions since the program join date become an international asset, so investments associated with the maintenance of those levels of emissions become an international responsibility too. Decreases in forest areas or increases in emissions in breach of commitment levels subject a participating country to penalties, much like the decreases in SDRs below the quota levels carry interest charges and penalties. Whether using IMF loans or external financing to achieve climate targets, countries have reasons to participate in SEAPs because they are mandatory for the accrual of SEDRs, a reserve asset (Figure 13).

Figure 13: Climate finance and reserves

Source: Author's illustration

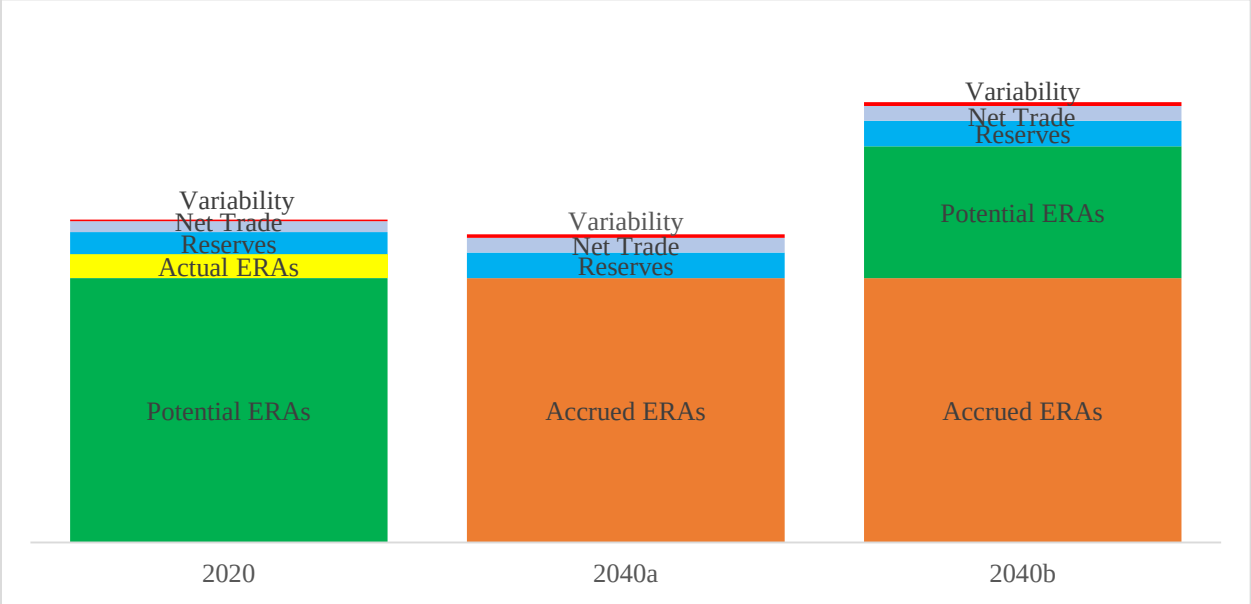
A country seeking the maximum possible IMF loan to preserve and improve its natural environment would commit its entire actual and potential ERAs. This would entitle it to leverage its entire ERAs to borrow SEDRs to finance the transition. Once the SEDRs are accrued, they become part of its reserve assets and can be used to access 20-year interest free loans from the IMF for environmental projects. Even if a country were not using any IMF loans, committing ERAs enables it to fully accrue the SEDRs resulting from improvement in natural assets over a 20-year period. At that point, a country retains the right, but not the obligation, to leverage its accrued ERAs to access IMF loans for environmental preservation activities. By committing ERAs, countries that choose to self-finance their programs would in effect be accepting a potential foreign-denominated liability if their targets are not achieved or if, at any time in the future, their ERAs fall below the commitment level. Without the commitment, a country that self-finances its transition would not receive this future funding option. Accruing SEDRs may therefore be an attractive proposition for countries with abundant foreign currency

assets seeking to diversify their reserve assets, or countries looking to accrue SEDRs using their domestic currencies through employment programs, environmental policies, and similar local activities.

E. Accrual and amortization schedules

Debt is amortized at the rate of reduction in potential ERAs based on a pre-agreed schedule in the SEAP specifying the range of qualifying outcomes. As a result, the accrual of ERAs takes place proportionally to the decrease in potential ERAs as measured in every quinquennial review, so that any loans from the IMF are fully amortized by improvements in environmental outcomes over a 20-year period. Since ERAs constitute the basis for SEDRs, the accrual of ERAs raises the capacity of participating countries to access finance in the future (Figure 14).

Figure 14: Maximum SEDR loans without potential in 2040a and with potential in 2040b

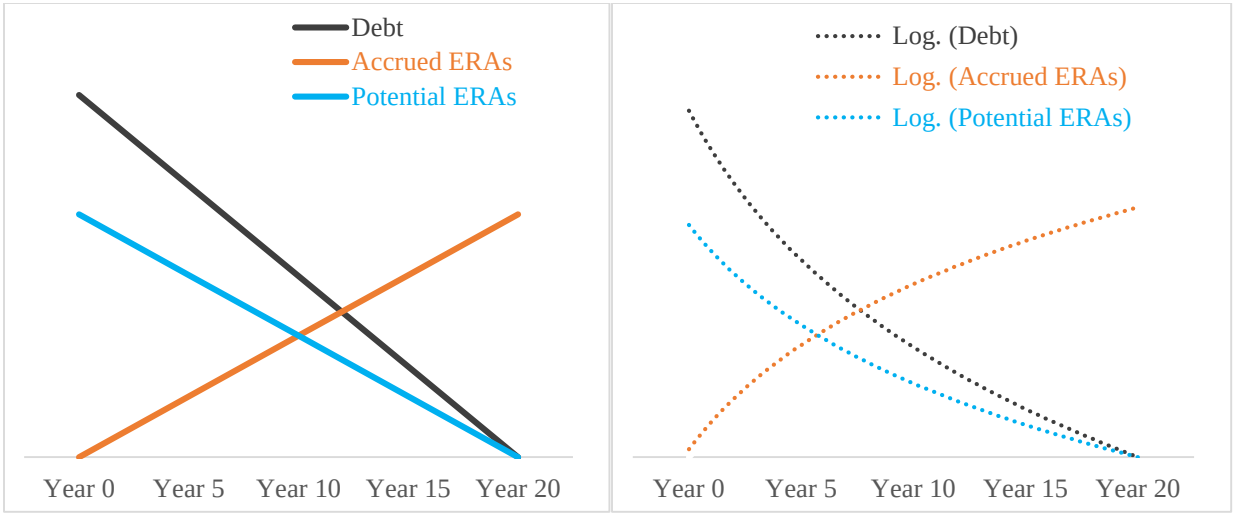


Source: Author's calculations

In year zero, a country would start off with a large debt liability due over a 20-year period, matched by an equivalent amount of non-accrued SEDR assets representing actual and potential ERAs and related activities. By year five, a participating country that achieves a portion of its targets for its potential ERAs accrues that increase in its ERAs and uses the rate of decrease in its potential ERAs to extinguish its debt liability at the same rate. This process continues until

the country's potential ERAs have been fully realized by year 20. After that, the total accrued ERAs allow a country to tap into IMF funding for up to its SEDRs to be used for maintenance projects. Accrued SEDRs in year 20 include the size of accrued ERAs with a weight of 67% plus related economic activities such as net trade in climate-friendly goods and services, variability of environmental imports, and non-SEDR reserve assets, which carry a weight of 30%. The country may, however, choose to seek additional SEDRs by submitting new improvement projects, which start off as potential ERAs and finish off as accrued ERAs over the following 20-year period.

Figure 15: Hypothetical linear and logarithmic trends for debt amortization and ERAs



Source: Author's simulations

Figure 15 illustrates hypothetical linear and logarithmic scenarios for all three schedules under one SEAP. Linear trends assume the reduction in potential ERAs is evenly divided over the four quinquennial periods, but in reality, the potential ERAs schedule is more likely to be concave up since the largest emissions reductions are achieved in the phase immediately following the transition from fossil fuels to renewable energy. As such, the debt schedule would also be concave up, and the accrued ERAs schedule concave down. Countries can add new potential ERAs under an updated SEAP starting year 5 following the accrual of ERAs, but those would likely increase at a slower pace in new SEAPs because of the physical and geographic limitations of expanding forest areas and protected areas for example. The debt schedule will differ from the potential ERAs schedule because the first reflects a country's total capacity to

draw on Fund resources in the first period, including actual ERAs with a weight of 3% as well as economic indicators such as net trade in climate-friendly goods and services, variability of environmental imports, and non-SEDR reserve assets. Reductions in potential ERAs will also be equal to the increase in accrued ERAs, so the two schedules will be negatively correlated.

F. Monitoring, evaluation, reporting, and verification (MERV)

MERV has been formally recognized as a part of climate change financing initiatives since at least the Bali Action Plan in 2007, which called for mitigation actions that are "measurable, reportable, and verifiable" (Fukuda and Tamura 2010, 39). It is generally used within the context of GHG emissions, but in this paper, we consider MERV to encompass a country's full list of ERAs, including its emissions, recognizing that producing accurate national emissions statistics is one of the most complex processes required for calculating ERAs. Favorable outcomes are required to fall within a range of feasible outcomes subject to pre-agreed ranges using MERV procedures for ERAs to be accrued and any associated loans to be amortized. The disbursement of funds, meanwhile, will be linked to satisfactory progress towards environmental reforms through projects and policies; outcomes feature only marginally in the formation of progress assessments, particularly in early years, given the lag between investment spending and the resulting environmental outcomes.

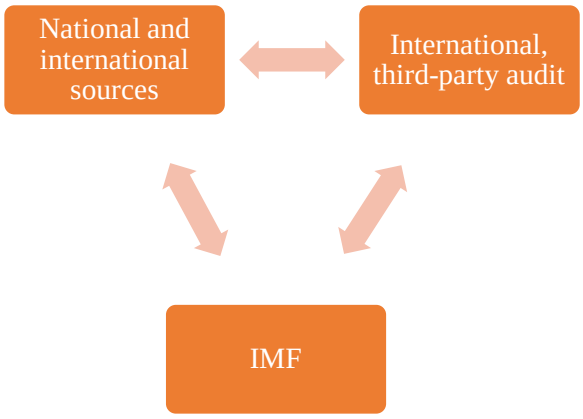
However, MERV methods are subject to great debate, especially between developed and developing countries when financial support is linked to tangible results and even more so when those results involve environmental outcomes that are challenging to measure and verify. Fukuda and Tamura (2010) contrast the preference among developing countries and the private sector for simple and easily compatible MERV schemes with developed countries' stringent, and often costlier, requirements particularly when linked to financial support. Nevertheless, costs associated with reporting and communication of emissions information by developing countries, but not necessarily measurement, in relation to external support, have gradually come under the responsibility of developed countries since as early as 1992. In particular, Article 12 of the 1992 UNFCCC states that "the developed country Parties and other developed Parties included in Annex II shall provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties in complying with their obligations under Article 12, paragraph 1 [Communication of Information Related to Implementation]. They shall also provide such financial resources, including for the transfer of technology, needed by the

developing country Parties to meet the agreed full incremental costs of implementing measures that are covered by paragraph 1 of this Article and that are agreed between a developing country Party and the international entity or entities referred to in Article 11 [Financial Mechanism], in accordance with that Article."

Regardless of the funding source, Fukuda and Tamura (2010) propose two approaches to address the trade-off between simplicity and stringency. They call for strengthening capacity building in developing countries in the quantification of emissions, including in the private sector whose lack of expertise serves as a barrier to the wider use of the Clean Development Mechanism (CDM). The authors also propose the development of new modalities and methodologies such as standardized baselines and default values which would be easier to implement in developing countries given the absence of need for monitoring during project implementation.

Under a SEAP, MERV takes place on an annual basis despite having quinquennial program reviews. The key objective of MERV is for the IMF as a creditor to gain complete and regular access, through a newly established climate finance department, to the participating country's ecological balance sheet to support both quantitative and qualitative assessments. MERV relies on public and private data supplied by domestic and international sources by leveraging technology and social engagement to reduce perception gaps, while verification is performed by independent international auditors (Figure 16).

Figure 16: High-level proposed MERV structure



Source: Author's illustration

The reporting process makes information available to all stakeholders using standardized reporting templates and commonly-used formats that facilitate access to data by the private sector and the public in order to promote participation in the achievement of national objectives. Verification involves a set of procedures, both technical and professional, that the main stakeholders implement to verify the credibility and accuracy of data and relevant estimates. Developed countries have significant MERV[14] experience in the quantification of GHG emissions to share with developing countries, and much of the costs associated with capacity building would be incorporated into the SEAPs.

Ninomiya (2012) identifies four distinct levels of MERV which can be distinguished by their purposes and nature. Emissions MERV at the organizational level is characterized by a high degree of stringency given their use in emissions trading and related financial instruments. Project-level MERV tracks emissions reductions associated with individual projects and requires a high level of accuracy because of their use in crediting schemes such as the CDM and the Verified Carbon Scheme (VCS), whereas policy-level MERVs, which quantify the emissions outcomes of specific policies and are used in Nationally Appropriate Mitigation Actions, are characterized by low levels of accuracy. The fourth type of MERV takes on GHG emissions at the national and sub-national levels, and typically follows well-established methodologies derived from guidelines by the Intergovernmental Panel on Climate Change to provide a medium level of accuracy. SEAPs would rely initially on project and policy-level MERV, but would also develop the other two types during the implementation period and as part of national programs to secure the participation of the private sector and local communities in environmental reforms.

The IPCC provides detailed methodologies to estimate changes in CO_2 emissions in five carbon pools: above-ground biomass, below-ground biomass, dead wood, litter, and soil organic matter, and in non-CO_2 GHG emissions for changes in land use for six categories of land use: forest land, cropland, grassland, wetland, settlements, and other land (IPCC 2016). It divides the different levels of details available into three distinct tiers, and provides guidelines for estimating GHG emissions in each tier. Tier I, the default method, requires the lowest level of detail, and can thus be applied by any country using IPCC calculation guidelines and guidance on how to acquire activity data. The Tier II method applies a mathematical structure similar to

[14] MERV is often used in the literature interchangeably with MRV.

Tier I, but requires country-specific data, often collected using field work to describe national circumstances, such as types of vehicles. Tier II is widely used for estimating emissions from road transportation, electricity generation, agricultural soils, industrial waste water and municipal solid waste, according to Janardhanan (2010). Meanwhile, Tier III leverages higher resolution land use and land-use change data by applying more complex modelling and methods. The IPCC (2016) also points out that improvements in the quality of results in all three tiers can be achieved using available spatial stratification data by type or extent of human activities or type of forests.

Data description

Forest areas

The Food and Agriculture Organization of the United Nations (FAO) defines forests as land spanning more than 0.5 hectares with trees higher than 5 meters (16.4 feet) and a canopy cover of more than 10 percent, or trees able to reach these thresholds on site. The definition excludes land that is predominantly under agricultural or urban land use as well as trees in urban parks and gardens. Forest areas are composed of primary forests, other naturally regenerated forests, and planted forests. Quinquennial data show that the global stock of forest areas has been on the decline since 1990 (Appendix, Figure 21). By 2015, forest areas had decreased by 3.1% to an estimated 40 million km^2 from 41.3 million km^2 in 1990, according to the FAO. The distribution of changes in forest areas was fairly balanced with 93 out of 233 reporting countries and territories showing an increase in their forest areas and 88 reporting a decrease, while they remained flat in the remaining 52.

The magnitude of losses in forest areas, however, displays a heavy concentration within a handful of countries; the top 5 countries reporting shrinking forest areas account for over 85% of the world's total net losses. Brazil alone lost 9.7% of its forest areas between 1990 and 2015, accounting for 41.2% of the world's shrinkage, followed by Indonesia which saw its forest areas cut by 23.2%, a reduction equivalent to 21.3% of the world's total for the period. Increases were similarly concentrated within a handful of countries, led by China, the United States, India, Russia, and Vietnam which together reported an aggregate increase of 769,593 km^2 in forest areas, equivalent to 68.4% of the total increase in forest areas between 1990 and 2015. China grew its forest areas by 32.6% to 2.08 million km^2, adding 511,807 km^2 to global forests in just

15 years. Marked improvements in China can be attributed to government programs aimed at mitigating land degradation and offsetting somewhat the country's carbon emissions. For example, the Grain-for-Green program launched in the late 1990s was designed to retire farmland susceptible to soil erosion and resulted in the reforestation of an estimated 280,000 km^2. Forests are important for mitigating the effects of climate change through their carbon sequestration capacity via the absorption of CO_2 released from burning fossil fuels.

Greenhouse gases

The IPCC defines greenhouse gases as "gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds." The primary GHGs in the Earth's atmosphere are water vapor, carbon dioxide, nitrous oxide, methane, and ozone, in addition to human-made GHGs such as halocarbons and other chlorine-and bromine-containing substances, sulphur hexafluoride, hydrofluorocarbons, and perfluorocarbons. Increases in the emission of man-made greenhouse gases into the atmosphere disturb the Earth's radiative balance, leading to an increase in the surface temperature with a wide range of climatological effects especially on sea levels and agriculture. Carbon dioxide makes up more than 76% of greenhouse gases contributing to global warming and climate change, followed by methane and nitrous oxide with 16% and 6% respectively (IPCC 2014). Global annual GHG emissions doubled to 53.5 GtCO2e in the forty-year period through 2012, an aggregate figure that includes CO_2 totals and all anthropogenic CH_4 sources, N_2O sources and F-gases (HFCs, PFCs and SF6). The latest preliminary data point to acceleration in GHG emissions in 2018 to 2.7% after relative stability in the period between 2014 and 2017 (Quéré et al. 2018).

Threatened species

Threatened species cover mammals, birds, reptiles, amphibians, fish, marine fish, freshwater fish, vascular plants, mosses, lichens, and invertebrates, based on data from the OECD. Species assessed as Critically Endangered (CR), Endangered (EN), or Vulnerable (VU) are referred to as "threatened" species. For the purpose of measuring ERAs, data are calculated as the number of threatened species multiplied by the headcount of each species. Not all species groups have been evaluated to determine their threat levels, but for those where more than 80% of the species has

been evaluated, the International Union for Conservation of Nature and Natural Resources (IUCN) reports the proportion considered to be threatened. The number of threatened species reached 27,159 species in 2019, half of which are plant species, among close to 100,000 species evaluated (Appendix, Figure 22 and Figure 23). There is significant potential for recovery by countries participating in SEAPs. Threatened species could be recovered through conservation measures such as reintroduction, habitat protection or restoration, legal protection, or harvest management, according to IUCN.

Protected areas

The United Nations' Sustainable Development Goals (SDGs) call for increasing the proportion of protected terrestrial and marine areas to help defend vulnerable plant and animal species as well as to safeguard biodiversity. Protected areas cover an estimated 15% of the world's terrestrial and inland waters, 10% of the coastal and marine areas within national jurisdiction, and 4% of oceans (UNEP-WCMC and IUCN 2016). An estimated 19.8 million km2 of terrestrial and inland water were recorded in the World Database on Protected Areas (WDPA) in 2016, covering 14.7% of the world's extent of these ecosystems, according to UNEP. The Convention on Biological Diversity held at Aichi, Japan in 2010 adopted 12 biodiversity targets, including the protection of at least 17% of terrestrial and inland water areas and 10% of coastal and marine areas by 2020. The convention highlighted the role of indigenous peoples and local communities in the management of protected areas through the integration of traditional knowledge into governance and management measures to achieve Aichi targets. Protected areas underpin sustainable development by helping slow the loss of biodiversity, improve food and water security, and increase the resilience of vulnerable human communities to cope with natural disasters, according to UNEP.

Freshwater abstraction

Freshwater abstracted is water removed, permanently or temporarily, from rivers, lakes, reservoirs, rainwater, or groundwater sources. Abstraction may take place by the water supply industry for distribution or directly by other types of activities for their own use. FAO defines the level of water stress as the ratio of freshwater withdrawn by major economic sectors over total renewable freshwater resources, after taking into account environmental water requirements. Higher water stress levels hinder the sustainability of natural resources and

impede economic and social development with a disproportionate effect on the most disadvantaged people. FAO data (Appendix, Figure 24) show that at least 23 countries experience water stress above 70%, including 15 countries that withdraw more than 100% of their renewable freshwater resources, well beyond the 25% threshold consistent with a sustainable use of water by people and the economy. Regions facing high water stress levels can reduce the abstraction of water by implementing modern techniques that increase the productivity and efficiency of water resource use, including wastewater reuse and direct use of agricultural drainage water. The UN's SDGs target a substantial increase in water-use efficiency by 2030 and call for ensuring sustainable withdrawals of freshwater and reduction in the number of people suffering from water scarcity.

Hazardous waste

The UN defines hazardous waste as waste that, owing to its toxic, infectious, radioactive or flammable properties, poses an actual or potential hazard to the health of humans, other living organisms, or the environment. Not only does chemical contamination pose grave damage to human health, but it also impacts genetic structures and reproductive outcomes and the environment. In particular, the UN estimates that 210,000 m^3 of waste, including spent nuclear fuel destined for final disposal, are generated worldwide from nuclear power production, and these volumes are increasing. Hazardous waste, however, is often mixed with other non-hazardous waste, such as domestic refuse, commercial and institutional wastes, construction debris, and street sweepings, posing challenges to the management and measurement of outcomes. Meanwhile, restoration, according to the UN[15], requires major investment as well as the development of new techniques. Investment would be used to implement sound management of chemicals throughout their life cycle and of hazardous waste to minimize significant adverse effects to humans and the environment. Some of the techniques include recycling of hazardous waste output, incinerating hazardous waste through controlled combustion either with or without energy recovery, landfilling of hazardous waste, or other techniques that similarly divert hazardous waste from the overall waste stream. At the same time, policies and oversight would be required to transform production approaches to minimize hazardous waste production and its transboundary movement.

[15] https://sustainabledevelopment.un.org/topics/chemicalsandwaste

Key advantages

Aside from its direct impact on the environment, the SEDRs financing mechanism would bring about a series of institutional, financial, economic, technological, and social benefits. The concept is predicated on the sharing of responsibilities for, and returns from, the world's natural assets. In effect, SEDRs globalize both the costs and returns from environmental outcomes. Even after a loan has been fully extinguished through favorable climate outcomes, a country is able to continue to unconditionally draw zero-interest funds to invest in the maintenance and upgrade of existing or new systems. To the extent that the technology allows, SEDRs make financing available to any country willing to transition to renewable energy and sustainable environmental practices. Access to foreign currencies is therefore conditional only upon the ability to achieve environmental targets. This way, SEDRs provide a sustainable financing mechanism to avoid the reversal of gains and ensure that the global natural environment is handed down from one generation to the other with as little degradation as is technologically feasible. At the same time, commitments are legally binding to countries receiving loans from the IMF or accruing SEDRs through self-finance, much like SDRs represent a potential liability by subjecting countries to penalties and charges if their holdings drop below the quota.

The mechanism builds on existing international and national institutions to deliver an effective global response to the challenges presented by climate change. Domestically, funding for capacity building and public policy advisory services would contribute to the strengthening of institutional frameworks and the rule of law across many rural areas in developing countries. In contrast to the current status of largely fragmented bilateral and multilateral international climate finance, SEDRs centralize financing and planning processes through the IMF, thus streamlining implementation and reducing MERV costs associated with developed countries meeting their climate donor commitments under various international accords. Furthermore, SEAPs would have a positive impact on global economic growth, trade, and employment. They would generate large, long-term demand for, and investment in, environmentally-friendly infrastructure, technology, and related services, which may stimulate additional private sector investment, particularly in research and development. Given their impact on domestic economic activity and their stabilizing effect on payments balances, SEAPs serve as a specialized form of international assistance for both donor countries and local authorities. Loans received under SEAPs may therefore reduce the need for other development aid and payments support, and

offer participating countries an alternative growth path that is not at the expense of the environment. Growth in non-environmental sectors would become subject to higher or rising environmental standards. Reforms would bring about a valuable proliferation of technology to the agriculture sector in developing countries, leveraging sustainable agricultural methods to increase productivity, preserve soil quality, and reduce deforestation. Agriculture, forestry, and land use contributed to 24% of global GHG emissions in 2010[16] (IPCC 2014), especially due to soil and manure management practices, livestock, and the cultivation of crops.

The largest source of gains for countries participating in SEAPs emanates from the increase in effective demand driven by IMF funding or domestic expansionary fiscal policy. Each national authority retains significant discretion in designing its own path towards the achievement of targets, although strategies will almost always involve demand-side management policies to reduce waste and improve energy efficiency. For example, countries could open up procurement processes to competitive bidding from the private sector and from indigenous community groups to ensure greater participation and sharing of the responsibility for delivering on climate commitments. SEAP spending would cushion business activity for Small and Medium Enterprises outside major cities through low-risk long-term public contracts and stable employment and income levels. Investments in the energy sector and in sustainable agriculture practices would help slow the brain drain and mitigate push factors for illegal immigration of unskilled worker as well as rural-to-urban migration. Furthermore, the implementation of projects in rural areas could stimulate additional public investment in transport infrastructure and facilitate access to public and private services by groups that were previously marginalized. National authorities may also leverage their long-term income streams of foreign currencies from the IMF to mobilize additional private sector investment in agriculture, transportation, and clean energy services. They may use them to extend the maturity of their domestic currency debt in line with their long-term economic objectives, and reduce risk premiums through innovative derivative instruments. International finance and the ramping up of public sector capital investment would serve as a long-term source of revenues for private businesses, helping develop domestic capital markets and spurring additional investment in research and development.

[16] Excludes carbon sequestration in biomass, dead organic matter, and soils, which is estimated to offset 20% of emissions from agriculture, forestry, and land use.

The SEDRs mechanism offers major advantages over other forms of climate finance, but it is still a challenging undertaking characterized by high execution risk, requiring that members of the IMF devise a novel international legal governance framework. The mechanism requires a joint commitment by the United States, European Union, Great Britain, Japan, and China, the members of the IMF with freely usable currencies, to supply their currencies to finance the SEAPs, and to commit to honor the indefinite financing rights provided by the SEDRs. Other countries with potential to become issuers of freely usable currencies over the span of the next several decades, but which may be net users of the SEDRs until then, would also likely need to make similar commitments. The legal framework would describe the repercussions for non-compliance and the terms of any potential divorce from the mechanism or from the IMF. The design of the SEAPs would also likely entail many conflicts of interest and disagreement over the feasibility and investment requirements for particular projects, so the application and voting rights processes should be transparent and incorporate lessons drawn from the pitfalls associated with the IMF's SAPs. Once a program is agreed, the disbursement of funds would be subject to policy and project execution milestones, much like the current SAPs, but not to environmental outcomes given the prolonged lag between spending and outcomes.

The IMF's dismal track record in the design and management of SAPs poses another challenge to the SEDRs mechanism. The climate financing mechanism proposed in this paper does not preclude structural reforms to the governance and management of the Fund itself, but maintains that the IMF's mandate in relation to liquidity, trade, payments crises, and global growth, in addition to its expertise in SDRs, specifically qualify it to at least operate the financial aspects of the SEDRs mechanism. Nonetheless, the mechanism could alternatively be implemented through a new special purpose international environmental agency if the necessary rights and jurisdictions, many of which would be close replicates of IMF mandates, were granted to such an organization. SEDRs could also be feasible under any major reserve currency issuer, especially the United States and the European Union, but its specificity would likely then entail some restrictions on the origins of imports, and the small size of the program may inadvertently deter participation by some large developing countries and thus diminish the effectiveness of the mechanism at reducing global emissions. Indeed, despite the IMF's dismal reputation, developing countries have remained regular clients of SAPs and other borrowing arrangements even though they are more comprehensive in their economic reach and more socially unpopular than the SEAPs would be expected to be. Orastean (2014) reveals that 119 emerging and

developing countries[17] received financial support at least once from the IMF between 1984 and 2013, the majority of which are reasonably expected to tap into SEDRs funds.

Key stakeholders

Most emerging and developing countries stand to gain from the SEDRs mechanism, but meeting the program's main objective of combating climate change still requires buy in from key stakeholders with different objectives. The Paris Agreement called for the "highest possible ambition" and recognized "common but differentiated responsibilities and respective capabilities, in the light of different national circumstances" (UNFCCC 2015, 4). The section below uses six countries with distinct current accounts, emissions reduction potential, and currency statuses (Figure 17) to make the case for SEDRs in achieving ambitious environmental targets and in empowering countries with different national circumstances to honor their climate change responsibilities, as creditors, debtors, or both, according to their capabilities and potential.

Figure 17: Key stakeholders by potential ERAs, current account, and currency type

Country	Potential for accrued SEDRs	Current account	Degree of monetary sovereignty
United States	High	Deficit	High
China	High	Surplus	High
India	High	Deficit	High
Germany	Low	Surplus	Low
Greece	High	Deficit	Low
Saudi Arabia	High	Surplus	Low

Source: Author's assessments

United States

Under the SEDRs mechanism, the United States would have the largest financial obligations to the IMF in the short and medium terms, reflecting the dominant role that the US dollar plays in central bank reserve assets and international trade. That share of global allocated reserves denominated in US dollar, however, reached 61.7% at the end of 2018, down from 69.3% in

[17] Out of 153 countries classified as emerging or developing in the 2013 edition of the IMF's World Economic Outlook. Data were based on the IMF History of Lending Arrangements database.

1998[18], while the Chinese Renminbi, Australian dollar, Canadian dollar, and the British Sterling all gained market shares over the same period. Meanwhile, the US dollar represented as of March 2019 an even smaller weight of 41.7% in the basket used to calculate the value of Special Drawing Rights. At the same time, the US is the world's second largest emitter of GHGs and holds one of the largest potential for SEDR accruals; US Nationally Determined Contributions (NDCs) stipulate a reduction of 26% to 28% in GHG emissions by 2025 relative to 2005, and by 69% to 76% by 2050 under the Obama Administration's mid-century strategy.

Any long-term forecasts for the value of the US dollar and its role in international finance and trade run into uncertainties over structural changes in geopolitical and economic systems, but hedging potential unfavorable outcomes can potentially be a less daunting undertaking. From the point of view of the United States, SEDRs represent an opportunity to acquire foreign liabilities over a very long horizon using the current value of the US dollar, a low-cost hedging mechanism against potential depreciation in the value of the local currency. The wide acceptability of the US dollar grants the US the choice to self-finance its SEAP or to borrow from the IMF, thus accruing a large stock of SEDRs that can be used indefinitely to borrow from the IMF. If China, the European Union, or any other major reserve currencies comes to dominate international finance in the future, the US would be able to access those currencies under 20-year zero interest loans, in effect at the favorable exchange rates prevailing today. Furthermore, as the role of other currencies, particularly the Renminbi, grows, the US liability in relation to SEDRs accrued by other countries declines and gradually shifts to the rest of the IMF's freely usable currencies. The US would also accrue additional SEDRs as the world's largest net importer of photovoltaic solar cells, bringing at least some relief to its large current account deficit. Meanwhile, the high degree of monetary sovereignty that the US currently enjoys would allow it to self-finance its SEAP, including any imports, without sacrificing employment and inflationary objectives. Instead, the country could leverage its monetary sovereignty to revamp its environmental infrastructure and expand research and development to potentially transition the country into a leading exporter of renewable energy technology and services. More directly, the US economy stands to gain considerably from effective global action towards achieving climate change targets. For example, without emissions reductions, damages to US coastal property resulting from sea-level rise and storm surge are estimated to

[18] Share of allocated reserves as reported by the International Monetary Fund.

reach US$5 trillion through 2100[19] along with an estimated 12,000 deaths annually in just 49 cities due to projected temperature extremes (EPA 2015).

China

As a new entrant into the IMF's freely usable currencies club, China's Renminbi stands to gain credibility and international validation through the SEDRs mechanism. By using its local currency to invest domestically, and accruing SEDRs for its environmental outcomes, China would be hedging the value of the Renminbi, much like any country with a high degree of monetary sovereignty. The world's largest emitter of GHGs has already pledged to reduce the emissions intensity of its output by 60% to 65% by 2030 compared to 2005, offering considerable potential for accrued SEDRs and a valuable opportunity to reverse the damages to air quality and from hazardous waste that have plagued the country's development. Meanwhile, the transition is unlikely to undermine China's export competitiveness given the global nature of the transition to climate-friendly development; the country earns a global commitment to raising environmental standards, thereby setting an implicit environmental floor on global competition that would avoid the export of environmental degradation from highly-regulated to least-regulated competitors. The opportunity is perhaps greatest for China given its previous success in implementing large-scale development projects such as the Grain-for-Green program which succeeded at converting and restoring cropland into forestland through direct public investment and the participation of over 32 million people (Dayne 2007). SEDRs would be especially appealing to China's policymakers because they provide an option to diversify the country's foreign reserves and an opportunity to invest chronic current account surpluses in the generation of an international reserve currency whose value is not linked to the economic performance of any single sovereign issuer. In the wake of the global financial crisis in 2009, Zhou Xiaochuan, former Governor of the People's Bank of China, called for reforming the international monetary system with the main objective of creating "an international reserve currency that is disconnected from individual nations and is able to remain stable in the long run, thus removing the inherent deficiencies caused by using credit-based national currencies" (Zhou 2009, 2). In addition, Zhou (2009, 3) proposed "an open-ended SDR-denominated fund based on the market practice, allowing subscription and redemption in the existing reserve

[19] Using a 3% discount rate.

currencies by various investors as desired," an idea not too different in practice from a 1980s proposal for a substitution account aimed at protecting US dollar reserve holders from possible depreciation. With the SEDRs, China would be able to rotate its current reserve holdings or future current account surpluses into environmental investments that would help it accrue more of this stable, long-term international reserve currency. Furthermore, as the world's largest net exporter of photovoltaic solar cells, China would be able to earn even more SEDRs by sharing technology and renewable energy capacity building with developing countries.

India

India's participation in the SEDRs mechanism would bring significant returns. The country has one of the world's fastest-growing economies and GHG emissions rates, but its current account deficits pose a threat to the sustainability of the current trajectory. Even worse, India is poised to bear a disproportionate share of the economic, social, and human damage caused by the planet's warming, despite lower accumulated contributions to GHG emissions in the post-industrial revolution period. As a result, India has a big stake in global climate change adaptation and stands to reap the benefits, in the form of avoided damages, if the Paris Agreement and other climate targets are reached. A SEAP would help India go beyond its unconditional NDCs of reducing emissions intensity per GDP by 33% to 35% by 2030 as compared to 2005, and to reach more ambitious targets which the country has already conditioned upon the transfer of technology and low cost international finance. Borrowing from the IMF to finance its SEAP would support India's transition to renewable energy and environmental conservation without worsening its payments deficit and without disrupting the pace of its economic growth, but would instead orient economic activity away from environmentally harmful activities and into the natural base. Those investments and their resulting accrual of SEDRs would give India's currency an implicit environmental backing and indefinite access to environmental loans that can be used in times of instability or economic downturn. The investments themselves could promote rural development through projects for the recovery of endangered species and sustainable agriculture with clear spillovers in terms of income equality and social justice.

Germany

Germany and the European Union bloc as a whole have succeeded at reducing their GHG emissions between 1990 and 2005, and target a reduction of 40% in GHG emissions by 2030

relative to 1990. Like the US, SEDRs would serve as a long-term currency hedge for Germany and the EU altogether, particularly if the ascent of emerging markets paves the way for more non-Euro reserve currencies or for an increase in the shares of existing ones. The country's export competitiveness would likely benefit from raising environmental standards in developing countries, thus relieving downward pressure on domestic real wages. Germany also already has a well-developed renewable energy industry, so exports would be expected to respond positively to higher incomes abroad and to growing demand for renewable energy, capacity building, and related services, which would add to accrued SEDRs through the Net Trade channel. Moreover, direct IMF lending to developing countries would relieve Germany from its climate finance commitments under the Paris Agreement and others, and the economic stimulus in developing countries would reduce development aid requirements. Within Europe, Germany could benefit from the SEDRs mechanism by investing some of its current account surpluses in R&D or in development projects in participating periphery countries on lower risk premiums.

Greece

Like the rest of the EU, Greece is targeting a 40% reduction in GHG emissions by 2030 relative to 1990, but the country has already achieved significant reductions after its economy shrank in the aftermath of the 2008 global financial crisis. Saddled with long-term debt and limited borrowing capacity, Greece would be able to use environmental investments to accrue foreign currency liabilities, without SEAP borrowings disrupting its payments balance or increasing its market debt obligations. The accrual of non-Euro reserves would reduce the country's financing risk, while spending under the IMF debt program would stimulate economic activity, helping it avoid recessions and high unemployment by investing in climate-related activities.

Saudi Arabia

Saudi Arabia is the world's largest exporter of fossil fuels, but its domestic consumption of oil also takes up at least a quarter of the output, leading to a tripling in the country's GHG emissions between 1990 and 2014. High dependence on fossil fuels to power the domestic economy and to attract foreign currency inflows led the Kingdom to adopt a conservative climate target of reducing emissions by 130 $MtCO_2e$ annually by 2030 relative to an ambiguous business-as-usual scenario. Despite ratifying the Paris Agreement, Saudi Arabia declared that it may even slash its targets by 2020 if the agreement appeared to pose an "abnormal burden" on

its economy. The country stands to gain significantly under the SEDRs mechanism given its large potential for emissions reductions, solar energy production and export, and environmental development. SEAPs would help Saudi Arabia transition its domestic economy away from its dependence on oil and gas exports for public revenues, and into renewable energy, especially for domestic use. They would reduce volatility in economic performance and payments balances that follow sharp swings in global prices. The long-term nature of SEDRs would match the long-term profile of expected gains from oil reserves, compensating somewhat for forgone revenues from its reserves. Saudi Arabia is endowed with large reserves of other commodities, including gold; the transition away from oil would stimulate the development of those resources. Finally, high dependence on oil exports and on the oil sector for economic growth raises external risk for Saudi Arabia as the world transitions to renewable energy, particularly if major energy users take advantage of SEDRs funds to replace their consumption of fossil fuels with cleaner forms of energy.

VIII. CONCLUSION

The accurate size of returns from an effective response to climate change is uncertain, but the returns are, to a great degree of certainty, positive and immense. Meanwhile, proposals to address climate change often ignore the social, economic, and financial contexts that gave rise to 250 years of environmental degradation the world has experienced since the industrial revolution. In the absence of an indefinite, universal commitment to environmental conservation, current solutions, even if partially effective, offer little by way of addressing underlying structural development challenges that can threaten to reverse any gains at any time. The paradigm of "growth at any cost" has led to an erosion of environmental "cushions of safety" and destabilized the natural ecosystem, threatening to undermine sustainable development particularly in the lowest-income countries and communities. Climate finance flows are constrained by high and rising aggregate public debt levels, while various forms of carbon taxes have proven socially unpopular. The SEDRs mechanism proposed in this paper embodies global monetary cooperation in order to increase the liquidity available for climate finance in any country that needs it.

The IMF and national authorities enjoy significant discretion in the design of environmental adjustment plans and the determination of conversion factors; further research would use modeling techniques to estimate the parameters for key countries, determine the sizes of their investment requirements, and reasonable ranges for conversion factors. To determine the maximum volume of SEDRs that can be created, future research would estimate the investment requirements necessary to eliminate all GHG emissions and hazardous waste production, reforest the maximum feasible amount of forested land area globally, protect other vulnerable ecosystem variants, and recover the populations of all threatened species.

SEDRs combine concepts from the IMF's SDRs with features from John Maynard Keynes's ICU proposal, Nicholas Kaldor's commodity reserve currency proposal, debt-for-nature swaps, and developing countries' proposed "link" during SDR debates in the 1960s. SEDRs are an adaptation of the SDR for climate-related financing and payments. They are allocated in a somewhat similar way as the "link" had stipulated, but instead of using national income as a measure of need, they use investment requirements for environmental conservation. As a result, SEDRs can be viewed as an SDR with a link to environmental development. Unlike debt-for-nature swaps, which depend on market conditions of foreign currency debt and involve separate

agreements, SEDRs offer regular access to finance as part of a national climate plan at a 100% discount rate subject to environmental outcomes. For developing countries, SEDRs treat the environment as a commodity reserve that ought to be maintained, an approach similar to Kaldor's commodity reserve currency, without any storage costs and with global and domestic benefits to hoarding. SEDRs also bear a close resemblance to Keynes's proposal for an ICU and share most of its objectives. They can be considered a form of environmental ICU whereby, instead of penalizing surplus countries, SEDRs grant them an option to earn future potential claims on IMF reserve currencies by financing domestic environmental projects.

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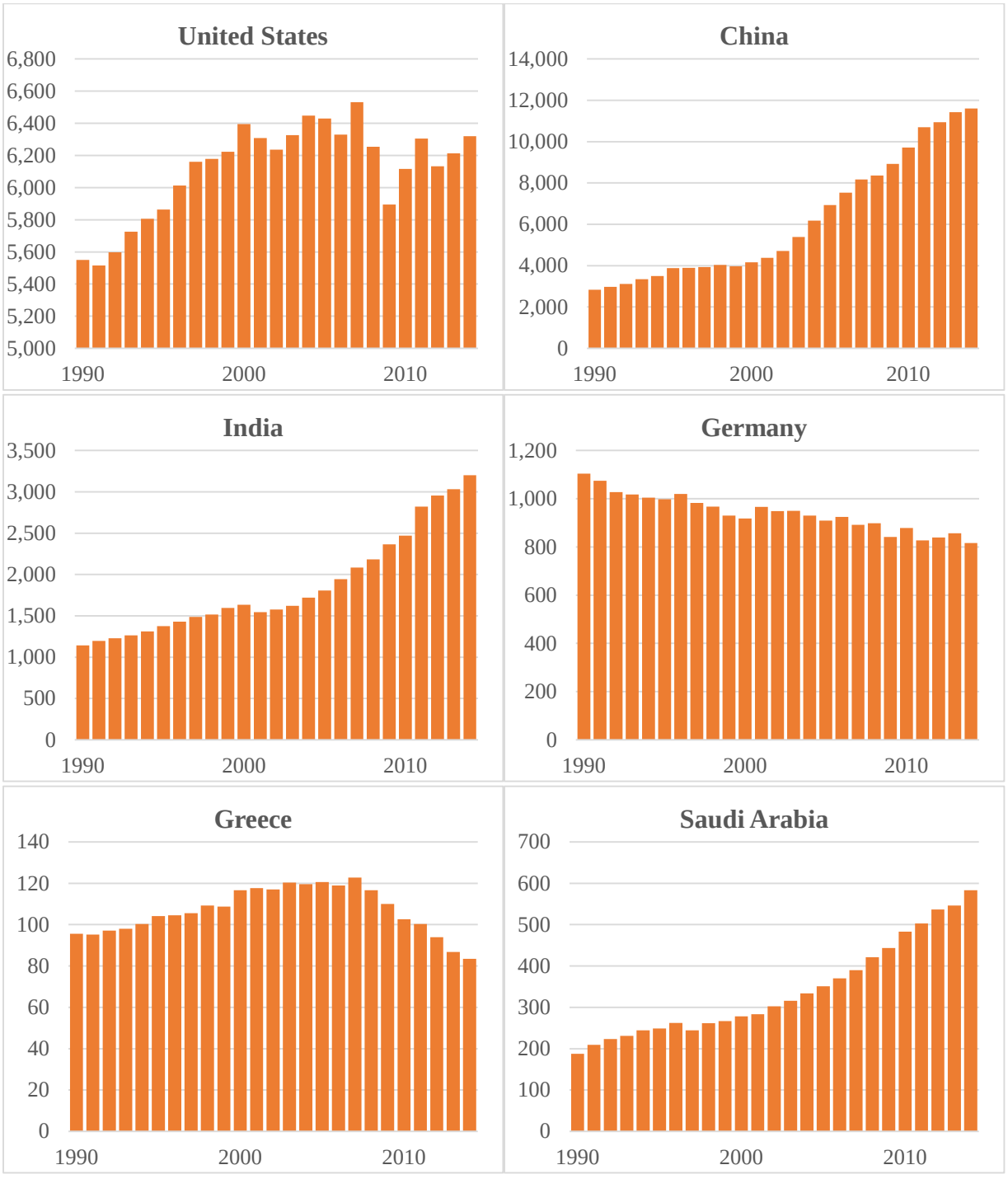
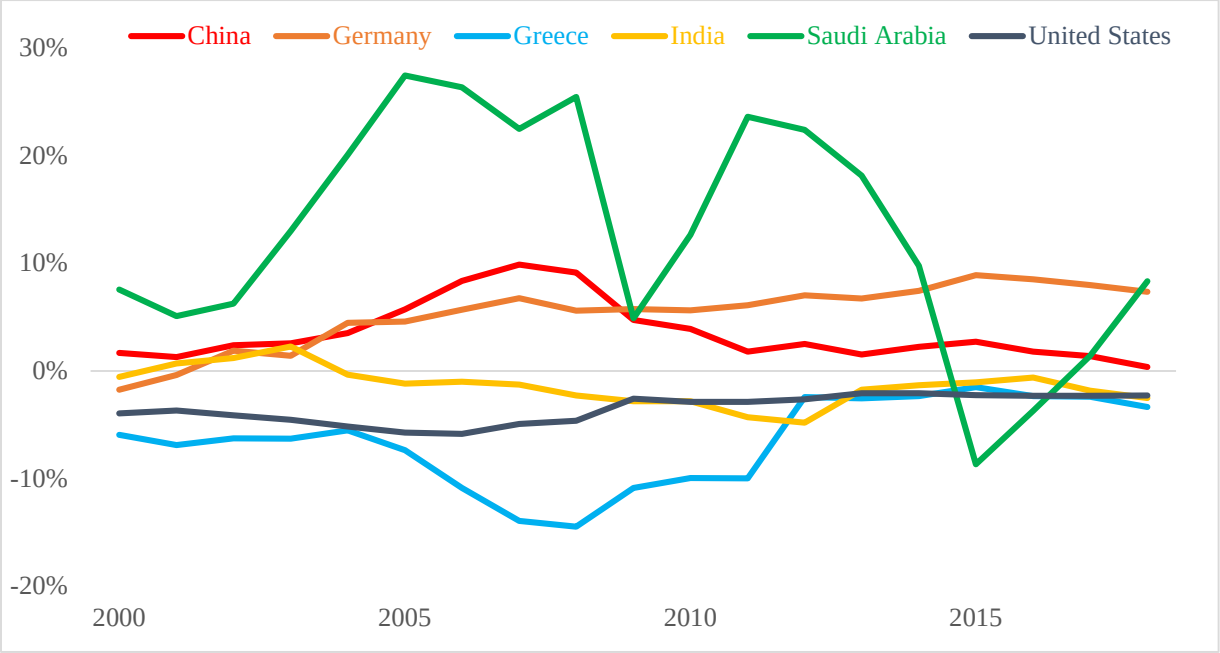
X. Appendix

Figure 18: Total GHG emissions ($MtCO_2e$) by country



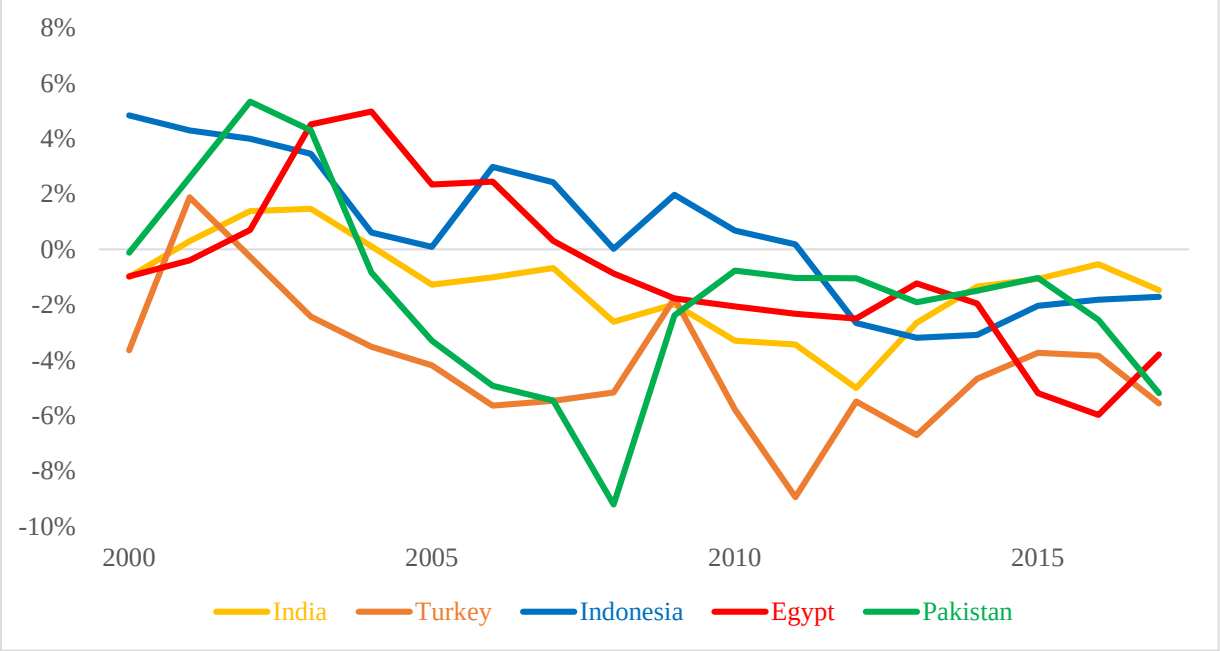
Source: CAIT Climate Data Explorer 2017

Figure 19: Current account balance (% of GDP)



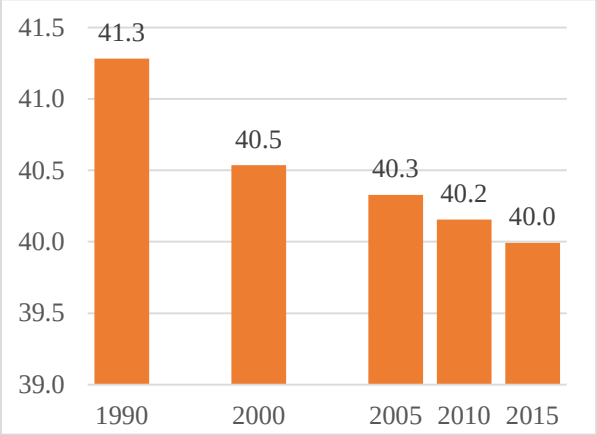
Note: 2018 data for Greece and the United States are estimates.
Source: International Monetary Fund, World Economic Outlook Database, April 2019

Figure 20: Current account balance (% of GDP) for countries building new coal plants



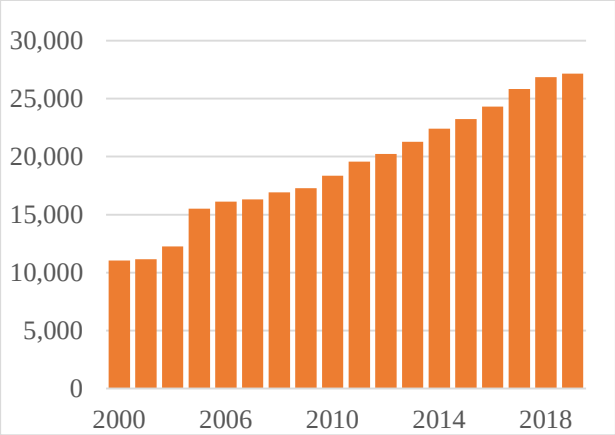
Source: International Monetary Fund

Figure 21: World forest area (km^2, millions)



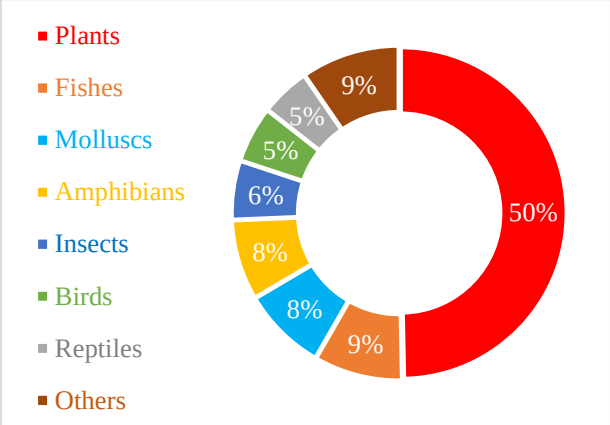
Note: Data missing for 1995 and 2005
Source: FAO

Figure 22: Threatened species



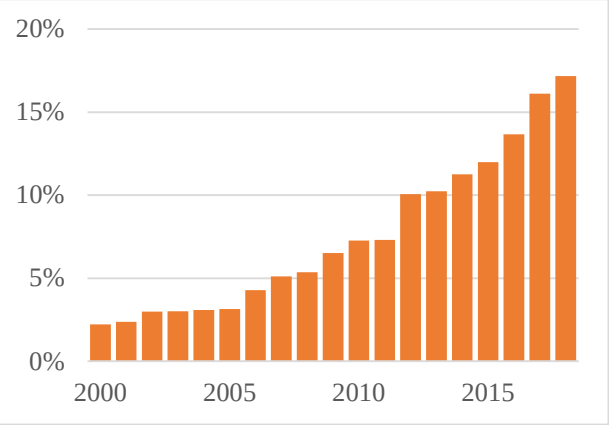
Note: Among evaluated species
Source: IUCN

Figure 23: Threatened species by type, 2019



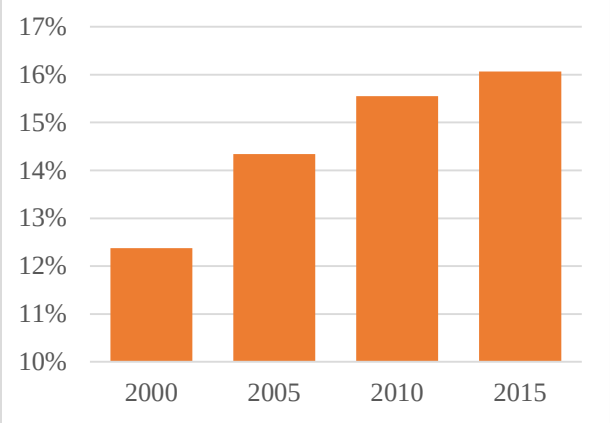
Note: Among evaluated species
Source: IUCN

Figure 24: Marine protected areas (% of EEZ)



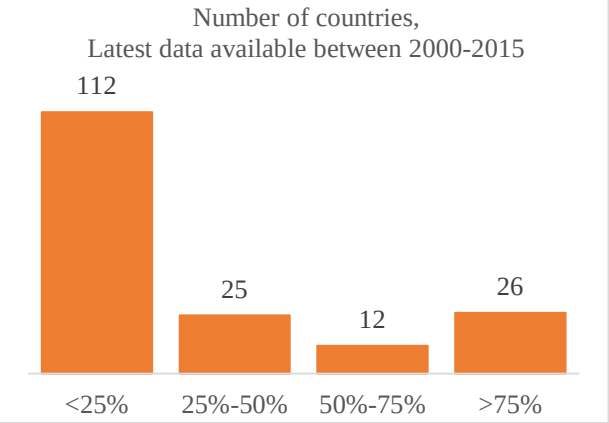
Note: In relation Exclusive Economic Zones
Source: UNEP-WCMC and IUCN

Figure 25: Protected forest areas (% of total)



Note: Within legally established protected areas
Source: UNEP-WCMC and IUCN

Figure 26: Distribution of water stress levels



Note: Withdrawal, % of available freshwater resources
Source: FAO