Infrastructure for Climate Change

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Climate change with its catastrophic effects are increasingly exacerbating economic, environmental, and political challenges on a global scale. The consequences of global warming, rising sea levels, and agricultural difficulties are profoundly affecting people's lives and inflicting severe damage on infrastructure. Recent years have underscored the inadequacy of existing infrastructure to withstand these escalating impacts. Key systems such as transportation, communication, drainage, and energy are deteriorating as climate change intensifies, highlighting the urgent need for resilient and adaptive solutions. Fortunately, there are solutions to the infrastructure problem, which include adaptive and mitigative types of infrastructure that can protect from, or adapt to, the effects of climate change. (See European Environment Agency, 2023). However, the costs to build these adaptive and/or mitigative infrastructures can be extremely costly. The costs of damage caused by extreme weather patterns is also expensive; Typically, in the billion-dollar range. (Dundas, 2017).This is a concerning problem specifically for the global south who are experiencing more heightened effects of climate change and who lack the economic and political stability to invest in this type infrastructure. Realistically, wealthier northern countries can provide funding to southern countries to combat the effects of climate change they are dealing with. The question is not if this can be done, but if northern countries will commit to doing this and who will hold them responsible. (United Nations, *Finance & Justice*)

Acting now and implementing adaptive or mitigative technology and infrastructure is key to managing both current and future effects of climate change. Adaptive infrastructure refers to the systems and structures designed to help communities and ecosystems adjust to the adverse effects of climate change. Many countries are faced with deteriorating infrastructure due to rising sea levels, constant natural disasters, and severe weather patterns. In response, they have begun to adopt various strategies. For example, several cities in India are applying strategies that address both infrastructure improvements and the effects of climate change on communities and people. The Japanese city of Sendai has developed some of the most resilient infrastructure assets, focusing on human resilience. (Chirisa et al., 2016). Though there are different beliefs in how to approach potential risk management and disaster risk reduction due to lack of extensive climate change predictions and data, it is believed that the best action to take is to find the best estimate of predicted climate conditions and build infrastructure adaptive to the estimated conditions. (Gibbs, 2015, p. 10).

In the situation where coastal communities experience flooding, rising sea levels, and coastal erosion, adaptive infrastructure can be a solution to the costly damages these have on infrastructure. Physical infrastructure like dikes and seawalls can be built or elevated to decrease the likelihood of flooding in treatment facilities. Water pumping/ pump stations can also help reduce flooding effects on storm water drainage systems. Lastly, elevating infrastructure would help reduce the probability of

flooding. There are other adaptive ways to ensure that infrastructure is not affected by climate change effects. New, improved, and adaptive infrastructure can be built such as submersible or water resistance equipment. (Azevedo De Almeida & Mostafavi, 2016). Deterioration of infrastructure due to climate change is seen with various building/ structural types. Concrete is one of the materials that sees extensive damage due to severe weather. Corrosion may be caused by carbon emissions, water, chloride (in water and soil), and atmospheric conditions. Time and severity of concrete exposed to these elements may lead to costly reparations. It was found that carbon induced damage
was evaluated at 400%, specifically in Australia. (Stewart et al., 2011). In cases like these, adaptive infrastructure is a necessity. Most infrastructures will deteriorate or be damaged by the effects of climate change which is why implementation of adaptive or mitigative technologies is crucial.

Mitigative infrastructure aims to reduce greenhouse gas emissions and slow climate change. This type of infrastructure would be the most beneficial as it addresses the root causes by lowering carbon emissions and enhancing carbon sequestration. Various types of mitigation include renewable energy infrastructure, carbon capture and storage, energy efficiency, and urban green spaces. Mitigative technology is an effective tool to help deal with and combat
climate change. For example, biofuel such as ethanol has been used since the 19th century to reduce carbon emissions. Ethanol GHG emissions are 44%-52% lower than gasoline. (Ethanol vs. Petroleum-Based Fuel Carbon Emissions, n.d.) It should also be noted that for water systems, a large amount of energy is required to extract and deliver freshwater to people, yet water is also needed for energy extraction. Current wastewater infrastructure accounts for 45 million greenhouse gas emissions per year in the U.S. (Pirne and Yonkin 2008). An alternative to this infrastructure is a bioelectric chemical process or fermentation process that utilizes fuel cells to generate electricity, or microbial electrolysis cells which treat wastewater. (Advancing Renewable Energy Technologies Committee, 2022, Chapter 6). These types of mitigative technologies drastically reduce carbon emissions.

Carbon capture and storage is another type of mitigation strategy that has proven successful. “Carbon capture and storage (CCS) is a way of reducing carbon dioxide (CO2) emissions, which could be key to helping to tackle global warming. It’s a three-step process, involving: capturing the CO2 produced by power generation or industrial activity, such as hydrogen production, steel or cement making; transporting it; and then permanently storing it deep underground.” (What Is Carbon Capture and Storage?, n.d.). There is also research being done to turn CO2 into usable fuel. (Engineers Develop an Efficient Process to Make Fuel from Carbon Dioxide, 2023). Carbon sequestration can also be used to reduce/remove CO2 from the atmosphere. Various types of carbon sequestration exist such as biological, geological, and technological. Biological carbon sequestration occurs through storing carbon in the ocean, in forests, or in soil. The utilization of graphene production, direct air capture, and engineered molecules are new types of technological carbon sequestration. (*Technological Carbon Sequestration*, 2021). Most carbon sequestration technologies

are aimed at capturing 90% of carbon. There are 45 operating commercial capturing facilities globally, totaling an annual capture of 50 Mt CO2. (Carbon Capture, Utilization and Storage - Energy System, n.d.). These technologies are successful and can greatly reduce the amount of carbon from the atmosphere, however, they are costly to build and to manage.

Costs of Adaption and Mitigation

The economic impact of infrastructure damage caused from climate change is acute. Climate related disasters also disproportionately affect developing countries compared to established countries who have the technology and economic ability to prevent and/or fix such damages. “Climate-related disasters have cost the world $650 billion over the last three years, and North America is shouldering most of the burden, according to a new report from Morgan Stanley”. (Di Christopher, 2019). Another cost aspect to note is the cost of implementing mitigative and adaptive infrastructure/ technologies. Countries face mounting economic concerns when it comes to dealing with damage caused by climate change such as rising sea levels, wildfires, CO2emissions, and more. Adaptive infrastructures that are built to withstand the most extreme weather events can cost up to billions, even trillions of dollars per year; an amount that many countries cannot afford.
(World Bank Environment Department)

The cost of mitigative infrastructure to address issues like climate change, natural disasters, and aging facilities varies widely by country and the scope of the projects. Globally, it's estimated that trillions of dollars will be needed over the coming decades. For instance, the Global Commission on Adaptation estimated that investing $1.8 trillion in climate resilience infrastructure by 2030 could yield $7.1 trillion in net benefits. Costs for individual countries depend on their specific needs, vulnerabilities, and economic capacities. For developing countries, the Global Commission on Adaptation highlighted that these nations might require hundreds of billions of dollars annually to build climate resilience. For instance, the UN Environment Programme estimated that developing countries will need $140-300 billion per year by 2030 for climate adaptation alone. International aid, development banks, and innovative financing mechanisms will be crucial in helping these countries meet their infrastructure needs. (Nations, n.d.).(United Nations Environment Programme., 2022, p. 27)

Funding Adaptation and Mitigation

For developing countries specifically, of which climate change affects disproportionately worse than wealthier countries, funding needs to be provided to these countries to combat the negative effects of climate change. In these countries environmental degradation is thought to be a driver of fragility and conflict, displacement of over 80 million people, increasing food insecurity, disease, and poverty. An estimated 100 million people will live below the poverty line by 2030. “A warmer climate could lead to an additional 250,000 people dying of diseases including malaria each year between 2030 and 2050, according to the World Health Organization.” (*Climate Change and the Developing World*, n.d.). There are multiple ways that the world can help developing countries fund adaptive and mitigative

infrastructure and technologies including the Adaption Fund, the International Development Association, and implementation of laws that require wealthy nations to provide funding for developing countries.

The Adaptation Fund was established under the Kyoto Protocol of the UN Framework Convention on Climate Change to finance projects and programs that help vulnerable communities in developing countries adapt to climate change. It aims to increase climate resilience through various initiatives, such as improving water management, agricultural practices, and disaster risk reduction. The fund is financed by proceeds from Clean Development Mechanism (CDM) project activities and other funding sources. Here is a map of the projects they have helped to finance around the world:

(afamin, n.d.)

Programs such as the International Development Association (IDA), part of the World Bank Group, provide concessional loans and grants to the world's poorest countries, aiming to reduce poverty, improve living conditions, and promote economic development. Established in 1960, IDA focuses on key areas such as poverty reduction, climate resilience, and support for fragile and conflict-affected states. It offers financial assistance through low-interest, long-term loans and grants to countries with per capita incomes of $1,255 or less. IDA's initiatives align with the Sustainable Development Goals (SDGs), significantly impacting global health, education, and infrastructure. It is financed through contributions from member countries, loan repayments, and IBRD transfers, with resources replenished every three years. IDA's support has led to notable

achievements, including reduced child mortality, increased school enrollment, and enhanced infrastructure development. (What Is Ida? | about | International Development Association - World Bank, n.d.). The IDA has provided $533 billion dollars to 115 countries.

The Paris Agreement is an example of an international treaty aimed at combating climate change. It was adopted by nearly every nation in 2015 during the United Nations Climate Change Conference (COP21) in Paris. The agreement represents a global effort to limit global warming to well below 2 degrees Celsius above pre-industrial levels, with efforts to limit the increase to 1.5 degrees Celsius. It sets out a framework for global climate action, including commitments from all participating countries to reduce greenhouse gas emissions, enhance resilience, and adapt to the impacts of climate change. Treaties like these are great for combating climate change globally, but more must be done soon. In 2009, COP15 was successful in getting countries to agree to fund climate change adaptation and mitigation for developing countries. These countries committed to mobilize $100 billion a year by 2020. (Terpstra, 2013). Developed countries succeeded in doing this, although two years late, in 2022. In total, 115.9 billion dollars was mobilized to developing countries for climate change funding. Most of this amount went to mitigation and only a third went to adaptation. However, this funding was mostly given as loans, adding to the debt burden developing countries already have. (*Developed Countries Reach $100 Bln Annual Climate Finance Target Two Years Late – OECD*, 2024).

(*Developed Countries Materially Surpassed Their USD 100 Billion Climate Finance Commitment in 2022*, 2024) This is highly beneficial in the long run, but studies suggest that developing
countries need an estimated $2 trillion dollars annually to meet a 2050 net-zero goal (mitigation). Much of the current funding comes from the public sector meaning that the private sector can and should contribute more financial aid to meet the trillion-dollar goal. (Black et al., 2023). The other problem is that debt that developing countries are accumulating due to funding loopholes from developed countries. Developing countries often face significant debt burdens, which are exacerbated by the need to finance climate adaptation and mitigation efforts. When developed countries provide loans instead of grants, it can increase the debt burden of these nations, pushing them further into debt distress. According to the International Monetary Fund (IMF), many low-income countries are already in debt distress or at high risk of it. (Terpstra, 2013). There is a broader issue of equity and fairness in international climate finance. Developing countries argue that developed nations, being historically responsible for most greenhouse gas emissions, should provide more support in grants rather than loans. This support is seen as part of a moral and ethical responsibility to address the disproportionate impact of climate change on poorer nations. To address these issues, there have been calls for more innovative financing solutions. These include debt-for-climate swaps, where debt is forgiven in exchange for investments in climate projects, and the use of special drawing rights (SDRs) from the IMF to fund climate action without increasing debt levels. **Solutions and Strategies**
There are various strategies to fight climate change, implement adaptation and mitigation globally, properly provide debt-free funding to developing countries, and create new laws, treaties, and commitments to increase funding and decrease CO2 emissions. A debt-for-climate swap aims to reduce the debt burden of a developing country while simultaneously funding mitigation and adaptation projects for climate change. Currently, there are around sixty countries that risk going bankrupt due to having to repay on loans. “58 of the developing countries most vulnerable to climate change have almost $500 billion of debt servicing payments [123] due in the next four years.” (*A New Wave of Debt Swaps for Climate or Nature*, n.d.). As part of these swaps, a country's debt is forgiven or restructured in exchange for environmentally friendly investments, renewable energy, or other climate-related projects. For example, the debt for nature swap between Belize and The Nature Conservancy has reduced Belize's external debt by 10% of GDP [127] and is helping to protect the western hemisphere's longest coral reef. (*A New Wave of Debt Swaps for Climate or Nature*, n.d.). Due to large amounts of debt, many of the world’s poorest countries risk going bankrupt in the next few years. Furthermore, an SDR can be exchanged for other currencies, used for loan repayments, obligations, pledges, interest payments, and quota increases. The use of SDRs reflects and promotes multilateral cooperation. SDR allocations are a product of collective action by IMF member countries, reinforcing the principle of international solidarity and cooperation in addressing global economic challenges. In summary, SDRs are beneficial because they enhance global liquidity, provide cost-effective reserve assets, support developing countries, contribute to

financial stability, offer flexibility, aid low-income countries, and promote multilateral cooperation. These attributes make SDRs a valuable tool for maintaining economic stability and supporting sustainable development. (*Special drawing rights,* 2024).

The United Nations has a profound responsibility not only to developing countries but to the entire world, given that the effects of climate change are pervasive and catastrophic, impacting every corner of the globe. These impacts range from mass displacement of populations due to rising sea levels and extreme weather events, to the spread of diseases and significant economic downturns. As climate change accelerates, these challenges become more pronounced, highlighting the need for immediate and concerted global action. The UN plays a critical role in regulating CO2 emissions through various international frameworks and agreements, such as the Paris Agreement. This landmark accord brings together nations to commit to reducing greenhouse gas emissions and to work collaboratively towards limiting global warming to well below 2 degrees Celsius above pre-industrial levels, with an ambition to limit the increase to 1.5 degrees Celsius. Achieving these targets requires stringent enforcement of regulations on fossil fuels, CO2 emissions, and other greenhouse gases.

Furthermore, the UN's Sustainable Development Goals (SDGs) provide a comprehensive blueprint for achieving a sustainable future for all. Goals such as SDG 13 (Climate Action) emphasize the urgent need to combat climate change and its impacts by integrating climate measures into national policies, improving education and awareness and mobilizing financial resources.

A critical component of this global strategy involves financial support to developing countries, which are disproportionately affected by climate change despite contributing the least to global emissions. Many of these countries are on the brink of bankruptcy and face dire consequences from climate impacts, such as severe droughts, floods, and food insecurity. Hence, it is imperative that funding be provided in the form of grants or debt-free assistance, enabling these nations to invest in resilience and adaptation measures without exacerbating their financial burdens. Developed countries, particularly those in the Global North, have a moral and practical obligation to support these efforts. This support is not merely an act of charity but a necessary investment in global stability and security. As climate change knows no borders, the repercussions of inaction will reverberate globally, affecting economies, health systems, and social structures across all nations. Moreover, innovative financial mechanisms, such as the Green Climate Fund (GCF) and debt-for-climate swaps, can play a pivotal role in channeling resources where they are needed most. These mechanisms not only provide immediate financial relief to vulnerable nations but also promote sustainable development and environmental conservation. In conclusion, the UN's responsibility extends beyond regulatory frameworks to fostering an environment of international cooperation and solidarity. Ensuring that stringent measures are enforced, and adequate funding is provided, particularly to the most vulnerable countries, is critical. The global community can mitigate the worst effects of climate change and work towards a sustainable and resilient future for all

when these types of solutions are implemented. Works Cited

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