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CLIMATE TARGETS AND FINANCIAL CHALLENGES IN THE GLOBAL SOUTH: THE CASE OF CARBON CAPTURE AND STORAGE

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Carbon Capture and Storage (CCS) is a key technology that holds the potential to contribute to a sustainable future. As per the name, CCS is a process of capturing carbon dioxide (CO_2) from stationary sources of carbon emissions and permanently storing it, or capturing atmospheric CO_2, either directly from the air (hereafter referred to as direct air capture, "DAC") or from a point source (like a large fossil fuel-powered thermal power plant), and then injecting it in the subsurface for storage. This description highlights CCS's capacity to operate as a viable mechanism for cutting down emissions in industrial sectors generally, and in hard-to-abate sectors particularly. In light of this, CCS technologies have the potential to contribute as an important tool to meet climate objectives in a variety of ways, and to become a key alternative for the decarbonization of industries across the globe. Notwithstanding this, the scalability and widespread adoption of CCS is inhibited by its associated costs. This paper investigates the relationship between climate change and CCS, and considers whether there is a role for CCS in the global climate agenda. The paper further pinpoints the financial challenges to the successful implementation of CCS particularly for developing and least-developed countries.

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1. INTRODUCTION TO CLIMATE CHANGE AND THE GLOBAL CLIMATE AGENDA

Climate change refers to a shift in average weather conditions, including measures such as temperature, humidity, rainfall, cloudiness, and wind patterns – and changes in the frequency or severity of these conditions.[1] The Earth's climate has changed throughout its history, in cycles that occur over very long periods of time, being a natural process. However, climate change is under unnatural acceleration due to the increase in the atmospheric concentration of greenhouse gases (GHG) that trap heat and cause global warming. GHG emissions, particularly CO_2, methane (CH_4), and nitrous oxide (N_2O) are primarily responsible for global warming. Methane emissions arise due to coal mining, agriculture, human activities, oil and gas production and distribution, biomass combustion, and municipal landfills;[2] and substantial emissions of CO_2 arise due to the burning of fossil fuels (e.g., coal, natural gas, and oils), solid waste, trees, and other biological materials.[3]

Global temperature has increased by 1°C since 1880, with two-thirds of the warming occurring since 1975, with an increase of 0.15-0.2°C per decade ever since.[4] Since 1990, scientists have suggested that the world has emitted almost half of all historical greenhouse gas emissions,[5] making the tackling of climate change both a challenging and high-priority goal.[6] According to a forecast by the World Meteorological Organization, there is an indication of a potential warming trend, suggesting

[1] https://www.climateassembly.uk/documents/5/Introduction_to_climate_change_FINAL_002.pdf

[2] D.E. Flores-Jimenez et al, 'Atmospheric Dispersion of Methane Emissions from Sugarcane Burning in Mexico' (2019) 250 Environmental Pollution 922-933. A.J. Turner, C. Frankenberg and E.A. Kort, 'Interpreting Contemporary Trends in Atmospheric Methane' (2019) 116(8) Proceedings of the National Academy of Sciences 2805.

[3] K.O. Yoro, A.J. Isafiade and M.O. Daramola, 'Sequential Synthesis of Mass Exchanger Networks for CO_2 Capture' in *Lecture Notes in Engineering and Computer Science: Proceedings of the World Congress on Engineering and Computer Science* (San Francisco, 23–25 October 2018) 503.

[4] NASA, 'NASA Earth Observatory: Global Temperatures' (2020) https://earthobservatory.nasa.gov/world-of-change/decadaltemp.php accessed 25 November 2021; J Hansen, R Ruedy, M Sato and K Lo, 'Global Surface Temperature Change' (2020) 48 Reviews of Geophysics RG4004.

[5] Global Carbon Project, *Supplemental Data of Global Carbon Budget, Version 1.0* (Canberra, 2021).; J Gütschow, A Günther and M Pflüger, 'The PRIMAP-hist National Historical Emissions Time Series (1750–2019) v2.3.1' (2021) 8 *Zenodo* 571.

[6] GP Peters, RM Andrew, JG Canadell, P Friedlingstein, RB Jackson, JI Korsbakken, CL Quéré, A Peregon, 'Carbon Dioxide Emissions Continue to Grow Amidst Slowly Emerging Climate Policies' (2020) 10 Nature Climate Change 3.

temperatures may become 1.1 to 1.8 degrees Celsius warmer than the 1850-1900 average in the years 2023-2027.[7] A United Nations report reveals significant land degradation, with 40% of global land affected, including 30% of cropland and 10% of pastureland. The report highlights a concerning trend of dryland expansion exceeding 1% annually in the past 50 years, impacting numerous countries in the global south, especially countries in Asia and Africa. If this trajectory continues, degraded land could reach an area comparable to South America by 2050.[8] According to a World Bank report, 80% of individuals experiencing crop failure and hunger globally are concentrated in Sub-Saharan Africa, South Asia, and Southeast Asia, highlighting the potential for 43 million individuals in Africa alone to fall below the poverty line by 2030 unless effective measures are implemented.[9]

Historically, the persistent use of coal during the Industrial Revolution (1750-1850) was followed by oil exploration and production by the end of the 19th century, and natural gas exploitation in the 20th century. This transition involving several carbon-emitting resources and their intensive use was discovered by 19th-century researchers to have an unintentional effect on the global climate.[10] As noted by Plass, "if no other factors change, man's activities are increasing the average temperature by 1.1C per century",[11] and the 20th century would see a 30% increase in the atmospheric $C0_2$ concentration. Plass' statement is close to current observations of a 1.1°C increase by 2020 above 1850–1900 levels, and a 24% increase in $C0_2$ concentration.[12] Since the pre-industrial era, anthropogenic CO_2, CH_4, and N_2O emissions represent 66%, 16%, and 7% of the

[7] World Meteorological Organization, *Global Annual to Decadal Climate Update* (WMO, 2023) https://library.wmo.int/doc_num.php?explnum_id=11629.

[8] United Nations, 'Climate Issues: Land' https://www.un.org/en/climatechange/science/climate-issues/land.

[9] World Bank, 'What You Need to Know About Food Security and Climate Change' (17 October 2022) https://www.worldbank.org/en/news/feature/2022/10/17/what-you-need-to-know-about-food-security-and-climate-change.

[10] J Fourier, 'Mémoire sur les températures du globe terrestre et des espaces planétaires' (1827) 7 Mémoires de l'Académie Royale des Sciences 569.; J Tyndall, 'On Radiation Through the Earth's Atmosphere' (1863) 25 Philosophical Magazine and Journal of Science 200.; S Arrhenius, *Worlds in the Making: The Evolution of the Universe* (Harper & Bros 1908); Harper & Bros: New York, NY, USA, 1908; G.N. Plass, 'The Carbon Dioxide Theory of Climatic Change' (1956) 8 Tellus 140–154. [CrossRef]

[11] G.N. Plass, 'The Carbon Dioxide Theory of Climatic Change' (1956) 8 Tellus 140 https://storage.googleapis.com/jnl-su-j-tadmo-files/journals/1/articles/3720/658bde6899325.pdf.

[12] Copernicus Climate Service, 'Surface Temperature | ESOTC' (2019)

https://climate.copernicus.eu/ESOTC/2019/surface-temperature.

global radiative forcing increase respectively.[13] In the past decade, CO_2 accounts for about 82% of the increase in radiative forcing with 85.5% of global CO_2 emissions coming from fossil fuels and industry, and the remaining from land-use changes.[14]

The establishment of the Intergovernmental Panel on Climate Change (IPCC) has not yielded any significant structural change in the nature of global energy consumption at present.[15] Although electric energy generation via renewable sources reached 27% in 2019 and is increasing,[16] there is no positive indication of any structural changes in the fossil fuel industry as the energy supply via fossil fuels has remained at a consistent 81%.[17] It is evident, however, that the world is indeed transitioning from a high to a low carbon economy, the main driver being the global surface temperature rise which has been correlated with the emission of anthropogenic CO_2 into the atmosphere.[18] The creation of the United Nations Framework Convention on Climate Change (UNFCCC) established an objective at the international level to stabilize GHG concentrations to prevent dangerous anthropogenic interference with the climate system. Notably, the Conference of the Parties (COP) is convened under the UNFCCC annually to assess global progress on combatting climate change. Through COP21, the Paris Agreement on Climate Change was adopted and implemented thereafter. The Paris Agreement essentially became one of the foremost action plans taken on a global scale, aiming to hold the global average temperature increase to *'well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels'*.[19] This goal is linked to the requirement that all countries work together to bring GHG emissions to net zero by the second half of the 21st century. However, emissions have continued to increase since the Paris Agreement was signed into international law in 2015, with a short-lived drop in 2020

[13] WMO, *Greenhouse Gas Bulletin* (Geneva, 2020).

[14] GP Peters, RM Andrew, JG Canadell, P Friedlingstein, RB Jackson, JI Korsbakken, CL Quéré, A Peregon, 'Carbon dioxide emissions continue to grow amidst slowly emerging climate policies' (2020) 10 Nat. Clim. Chang. 2020 3–6.

[15] J.S.T. Pedersen et al, 'An Assessment of the Performance of Scenarios Against Historical Global Emissions for IPCC Reports' (2021) 66 *Global Environmental Change* 102199.

[16] International Energy Agency, *World Energy Balances 2020: Total Primary Energy Supply (TPES) by Source, World 1990–2019* (IEA 2021) https://www.iea.org/statistics.

[17] Ibid.

[18] Hon Chung Lau, Seeram Ramakrishna, Kai Zhang, and Adiyodi Veettil Radhamani, 'The Role of Carbon Capture and Storage in the Energy Transition' (2021) Energy & Fuels.

[19] Paris Agreement (2015) art 2.

due largely to the COVID-19 pandemic crisis,[20] with CO_2 emissions rebounding to 36 GTCO2 in 2021.[21]

To meet the aspirations of the Paris Agreement, research suggests that most countries need to achieve net-zero by mid-century. Net zero refers to the balance between the amount of GHG that is produced and the amount that is removed from the atmosphere.[22] This goal can be achieved through a combination of emission reduction and emission removal. It should be noted that the Paris Agreement itself is an international treaty, meaning that its provisions are subject to a degree of legal force internationally, meaning that its aspirations go beyond casual diplomacy and are embedded in long-term international law.[23]

Although Carbon, Capture and Utilization could represent a game-changing role for Carbon, Capture, Utilization and Storage (CCUS) projects, it has yet to find commercial applications. So, we will focus on the CCS challenges and perspectives even though we might make specific references to CCUS projects. So, after the introduction, this paper will cover the concept of CCS and its role in the climate agenda. Later it will cover the financial opportunities and challenges for the global south, followed by selected experiences in the global north. Finally, the paper will provide its lessons learned, recommendations and conclusion.

2. THE CONCEPT OF CCS AND ITS ROLE IN THE CLIMATE AGENDA

CCS refers to a process of capturing CO_2 from stationary sources of carbon emissions before it is released into the atmosphere[24] and permanently storing it, or capturing atmospheric CO_2, either directly from air (hereafter referred to as direct air capture, DAC) or from a point source (like a large fossil fuel-powered thermal power plant),

[20] C Le Quéré, C, RB Jackson, MW Jones, WJ Matthe, AJP Smith, S Abernethy, RM Andrew, AJ De-Gol, DR Willis, Y Shan et al, 'Temporary Reduction in Daily Global CO_2 Emissions During the COVID-19 Forced Confinement' (2020) 10 Nature Climate Change 647

https://www.imf.org/en/Blogs/Articles/2022/06/30/greenhouse-emissions-rise-to-record-erasing-drop-during-pandemic.

[21] International Energy Agency (IEA), *Global Energy Review 2021* (IEA, Paris 2021).

[22] National Grid, 'What Is Net Zero?' https://www.nationalgrid.com/stories/energy-explained/what-is-net-zero#:~:text=We've%20all%20heard%20the,emission%20reduction%20and%20emission%20removal.

[23] D Bodansky, 'The Legal Character of the Paris Agreement' (2016) 25(2) Review of European, Comparative and International Environmental Law 142.

[24] T Wilberforce, AG Olabi, ET Sayed, K Elsaid, MA Abdelkareem, 'Progress in Carbon Capture Technologies' (2021) 761 Science of the Total Environment 143203, 10.1016/j.scitotenv.2020.143203

and then injecting it in the subsurface for storage.[25] It consists of a group of technologies that can satisfy climate objectives in a variety of ways, and become a key alternative for the decarbonization of industries across the globe. According to the IPCC's Fifth Assessment Report, without the adoption and deployment of various CCS technologies, global atmospheric carbon concentration will increase by 138%. CCS is therefore a key technology that holds the potential to contribute to a carbon-neutral and sustainable future. CCS can play four (4) key roles in the achievement of net zero emissions, including; tackling emissions from existing energy assets, providing a platform for low-carbon hydrogen production, serving as a solution for sectors with hard-to-abate emissions, and directly removing carbon from the atmosphere.[26]

The Global South, in accordance with the UNFCCC's acknowledgment of common but differentiated responsibilities,[27] is granted a period of grace in the achievement of CO_2 emissions reduction. This circumstance comes with the understanding that developing countries are still dependent on CO2-emitting energy sources and industrial practices. However, CCS is advantageous in its ability to help the Global South meet its climate challenges as CCS technology can be retrofitted into existing plants, allowing for a continued operation of existing CO_2 emitting stationary facilities, as well as associated infrastructure and supply chains, but with significantly reduced emissions. The deployment of CCS as a compliment to preexisting plants is a positive factor in preserving employment and maintaining economic prosperity for the emission-dependent countries.[28] Notwithstanding this, the timing of achieving net-zero emissions plays a crucial role in meeting global climate objectives. Earlier attainment translates to a greater likelihood of success in reaching the most ambitious goals. In the power generation and industrial sectors, several options exist for mitigating locked-in emissions, provided as:[29]

[25] L.N. Nazarian et al, 'Imaging Algorithms for Evaluating Suspected Rotator Cuff Disease: Society of Radiologists in Ultrasound Consensus Conference Statement' (2013) 267 Radiology 589; F.O. Pires et al, 'The Influence of Peripheral Afferent Signals on the Rating of Perceived Exertion and Time to Exhaustion During Exercise at Different Intensities' (2011) 48 Psychophysiology 1284.

[26] IEA, *Energy Technology Perspectives 2020 - Special Report on Carbon Capture Utilisation and Storage: CCUS in Clean Energy Transitions* (OECD Publishing, Paris 2020) https://doi.org/10.1787/208b66f4-en.

[27] United Nations, *United Nations Framework Convention on Climate Change (UNFCCC)* (1992) https://unfccc.int/resource/docs/convkp/conveng.pdf.

[28] IEA, *Energy Technology Perspectives 2020 - Special Report on Carbon Capture Utilisation and Storage: CCUS in Clean Energy Transitions* (OECD Publishing, Paris 2020) https://doi.org/10.1787/208b66f4-en.

[29] Ibid

a. Investing in modifications to existing industrial and power equipment to either use less carbon-intensive fuels or improve energy efficiency.
b. Retiring plants before the end of their normal operating lifetimes, or making less use of them (e.g., by repurposing fossil fuel power plants to operate at peak-load rather than baseload).
c. Retrofitting CO_2 capture facilities and storing (CCS) or using (CCU) the CO_2.

For developing countries to meet the ambitious climate goals established by the global community, a combination of the three options noted above can be important; however, factors such as economic viability, social acceptability and implications for energy security must also be taken into account. Additionally, the early retirement of assets often carries significant financial burdens for both plant owners and governments, particularly in developing economies with newer infrastructure. Retrofitting such assets with CCS technology can potentially offer a more economical alternative to early retirement by extending their operational life. This approach can benefit plant owners through asset protection strategies, but its cost-effectiveness hinges on several factors, including the implemented carbon pricing mechanisms and available policy incentives.

From a broader economic standpoint, retrofitting CCS is generally most favorable for younger, more efficient power plants and industrial facilities situated near sites suitable for CO_2 utilization (e.g., Enhanced Oil Recovery - EOR) or storage. Additionally, locations with limited alternative generation or technological options for emissions reduction further enhance the viability of CCS retrofits. This approach should be carefully evaluated based on specific plant characteristics, regional infrastructure, and prevailing economic frameworks.

More significantly, it is noteworthy that the wider adoption and deployment of CCS, especially in developing countries, is inhibited by its associated high costs, due to the intensive capital expenditure required to set up CO_2 transport and storage infrastructure, for example.[30] The estimated costs of CCS projects in various subsurface formations require upfront capital and large investments for such infrastructure.[31] Apart from the upfront capital needed to establish CCS project infrastructure, CCS technology incurs technical costs in three key areas; capturing CO_2 emissions,

[30] M Bui et al, 'Carbon Capture and Storage (CCS): The Way Forward' (2018) 11 Energy & Environmental Science 1062-1176

[31] A.B. Rao and P Kumar, 'Cost Implications of Carbon Capture and Storage for the Coal Power Plants in India' (2014) 54 Energy Procedia 431-438; W.J. Schmelz, G Hochman and K.G. Miller, 'Total Cost of Carbon Capture and Storage Implemented at a Regional Scale: Northeastern and Midwestern United States' (2020) Interface Focus 10. & E.S. Rubin and H Zhai, 'The Cost of Carbon Capture and Storage for Natural Gas Combined Cycle Power Plants' (2012) 46 Environmental Science & Technology 3076-3084.

transporting them to storage sites, and securely storing them underground. There is also the challenge posed as a result of the current lack of commercially viable CO_2 utilization options, which makes CCS commercially unattractive. Notwithstanding these challenges, CCS has increasingly gained momentum as a viable technology capable of eliminating the principal anthropogenic gas from the atmosphere, while also permitting the exploitation of fossil fuels that power the present civilization. Hence, current CCS research and development are driven by the need to make the technology more affordable and accessible so as to accelerate its implementation in tackling climate change.[32]

3. FINANCIAL CHALLENGES AND OPPORTUNITIES FOR THE SUCCESSFUL IMPLEMENTATION OF CCS IN THE GLOBAL SOUTH

Notwithstanding that CCU and CCS increasingly attract significant momentum as a viable strategy for addressing global warming and climate change, finance poses a major challenge to the implementation of CCU and CCS projects. The implementation of CCU and CCS projects entail various activities ranging from the building and operation of capture infrastructure, to the building of transportation pipelines and secure storage facilities, which are generally expensive and require high upfront investment costs. This is in addition to the energy requirement of carbon capturing and compressing, which increases the overall associated costs of CCU and CCS projects.[33] Although high capital costs for CCU and CCS development and deployment are generally applicable, this is particularly relevant to developing and least developed countries, considering the level of their technological advancement and the financial resources available to them in comparison to developed countries. Realizing the unequal pedestal upon which developing and developed countries stand, and in line with the principle of common but differentiated responsibility, the United Nations through the sustainable development agenda called for the revitalization of global partnership to enhance the implementation of the various global developmental goals.[34] Specifically, the agenda seeks a global partnership among all countries, stakeholders

[32] M Shen, F Kong, L Tong, L. et al, 'Carbon Capture and Storage (CCS): Development Path Based on Carbon Neutrality and Economic Policy' (2022) 1 Carbon Neutrality 37 https://doi.org/10.1007/s43979-022-00039-z.

[33] DBRS Morningstar, 'High Investment Costs and Untested Technology are Challenges for the Carbon Capture Industry' (10 October 2023) https://dbrs.morningstar.com/research/421543/high-investment-costs-and-untested-technology-are-challenges-for-the-carbon-capture-industry accessed 10 June 2024; CECO Environmental, 'Barriers to Successfully Implementing Carbon Capture, Utilization, and Storage (CCUS)' (25 April 2024) https://www.cecoenviro.com/barriers-to-successfully-implementing-carbon-capture-utilization-and-storage-ccus/ accessed 10 June 2024.

[34] Eduardo G Pereira, Thomas L Muinzer and Patrick R Baker, *Energy Law and the Sustainable Development Goals: Host Government Instruments for Sustainability in Oil and Gas Operations* (Routledge 2024).

such as the private sector, and people with particular focus on the needs of the poorest and most vulnerable countries, including least developed and developing countries.[35] Some forms of global partnership supported by the UN in this regard include; implementation of official development assistance (ODA) commitments by developed countries to developing and least developed countries, mobilization of additional financial resources for developing countries from multiple sources, and the adoption and implementation of investment promotion regimes for developing countries. Additionally, the UN emphasizes the need for concerted efforts by different sectors and actors through multi-stakeholder partnerships to pool financial resources, knowledge and expertise for the implementation of developmental goals, particularly in developing countries. Such multistakeholder partnerships may include voluntary initiatives undertaken by national governments, inter-governmental organizations, as well as other major stakeholders, such as corporations, whose efforts are capable of enhancing the implementation of developmental goals.[36] Hence, financing opportunities for CCS projects in developing countries may include: public finance through government funding, international public finance such as ODA, sustainable finance, corporate funding, as well as other innovative climate finance strategies.

i. Government Funding

The achievement of development goals hinges on substantial effort by individual nations on the basis that each country has the primary responsibility for its own development.[37] To this end, the sustainable development agenda highlights the important role of national parliaments through the enactment of relevant laws, as well as national policies and development strategies such as the adoption of budgets and ensuring accountability for the effective implementation of sustainable development commitments.[38] The United Nations also emphasizes the role of domestic resources, and the need to ensure that all available domestic funding sources and mechanisms are utilized.[39] It is noteworthy that such domestic resources will primarily include taxation and other such public levies that generate internal revenue for national governments. Illicit financial flows (IFFs) and other forms of capital flight, however, constitute a development challenge to developing countries in this context. As noted by the United

[35] United Nations, *Transforming Our World: The 2030 Agenda for Sustainable Development* (UN 2015) paras 22 and 39.

[36]United Nations, 'Science, Technology and Innovation for the SDGs' https://sdgs.un.org/topics/science accessed 10 June 2024.

[37] See the United Nations, *Johannesburg Plan of Implementation of the World Summit on Sustainable Development* (2002) para 81. See also United Nations, *The Future We Want: Report of the United Nations Conference on Sustainable Development* (Rio de Janeiro, 20–22 June 2012) para 252.; United Nations, *Addis Ababa Action Agenda of the Third International Conference on Financing for Development* (2015) para 9.

[38] Ibid. See also United Nations, *Transforming our World: The 2030 Agenda for Sustainable Development, op cit.,* paras 41 & *45.*

[39] United Nations, *Report of the United Nations Conference on Environment and Development (Agenda 21)* (Rio de Janeiro, 3–14 June 1992) para 33.14.

Nations, corruption and IFFs constitute a significant barrier to the effective mobilization and allocation of domestic resources for sustainable development.[40]

Therefore, the avoidance of IFFs and other forms of capital flight from developing countries constitutes an integral and significant aspect of the mobilization of financial resources needed to finance sustainable development in developing countries.[41] Relevant actions in this regard may include the setting of clear and concise tax laws and regulations, and the development of a political will to monitor and enforce compliance with such laws and regulations. Also, international cooperation, especially in the areas of the repatriation of such IFFs and the prosecution of perpetrators, is significant to ensure an end to such practices on one hand, and retention of beneficial development capital in developing countries on the other.[42]

ii. International Public Finance

Although the sustainable development agenda recognizes that nations are primarily responsible for their own development, it also emphasizes the role and significance of international public finance in complementing national efforts and mobilizing additional resources, especially in least developed and developing countries with limited domestic resources.[43] This is similar to Agenda 21 of the United Nations, which affirms that even though financing for sustainable development will come from national public and private sectors, least developed and developing countries will require external funding as a major source of substantial and additional funding for sustainable development.[44] This is pursuant to the international environmental law principle of common but differentiated responsibilities, which asserts that States have common but differentiated responsibilities in the conservation, protection and restoration of the environment. This is in view of the different levels of contributions by States to global environmental degradation, and it is also driven in part by recognition of the pressures that developed countries place on the global environment, as well as the technologies and financial resources that these countries command.[45] Thus, Agenda 21 encourages the mobilization of higher levels of foreign direct investments (FDIs) and technology transfers through national policies that promote such investments, and through joint ventures and other such legal structures.[46] As affirmed by the World Summit on Sustainable Development, greater flows of FDIs are important in affording support for sustainable development initiatives, including infrastructural development in

[40] United Nations, *The Future We Want*, op cit, para 266.
[41] United Nations Economic and Social Council, *Follow-Up and Review of the Financing for Development Outcomes and the Means of Implementation of the 2030 Agenda for Sustainable Development* (2018).
[42] Ibid.
[43] United Nations, *Transforming Our World: The 2030 Agenda for Sustainable Development*, op cit, paras 41 and 43. See also "The Future We Want" op cit., para 252; the 'Addis Ababa Action Agenda' op cit., para 50.
[44] 'Agenda 21' op cit., para 33.13.
[45] Report of the United Nations Conference on Environment and Development 'Rio Declaration on Environment and Development' 1992, principle 7.
[46] 'Agenda 21' op cit., para 33.15.

developing countries and least developed countries. Such FDIs supplement the domestic resources mobilized by developing and least developed countries.[47] Several international instruments on climate change recognise the need for countries with more financial resources, particularly developed countries, to financially assist developing and least developed countries, who are more vulnerable to climate change and less financially endowed, in implementing their climate obligations.[48] According to the UNFCCC, developed country-parties are required to provide financial resources to meet the agreed full costs incurred by developing countries in complying with their climate commitments and obligations under the Convention.[49] Such developed countries are also vested with the responsibility to adopt practicable steps to promote, facilitate and finance access to the transfer of environmentally sound technologies to developing country-parties.[50] Likewise, pursuant to the Paris Agreement, developed countries a have the responsibility to provide financial resources to assist developing country-parties with respect to their climate commitments under the UNFCCC.[51]

Hence, various sources of international public finance that could be harnessed by developing countries for the funding of sustainable development projects such as CCS include: FDIs, ODAs,[52] export credits or other financial instruments from international financial institutions, etc. The Clean Development Mechanism (CDM) established under the Kyoto Protocol can also play a significant role in this regard. The Kyoto Protocol is no longer in effect, but the mechanism has been sustained under the terms of the Paris Agreement.[53] The CDM allows developed countries with emission reduction commitments under the UNFCCC, the formerly operative Kyoto Protocol, and the Paris Agreement to implement emission abatement projects in developing countries, and to receive certified emission reductions credits as a way of complying with their climate commitments.[54] The CDM was established to assist developing countries in achieving their climate goals and obligations, while also assisting developed

[47] Johannesburg Plan of Implementation of the World Summit on Sustainable Development op cit., para 84.
[48] See for instance, the United Nations Framework Convention on Climate Change 1992, and the Kyoto Protocol to the United Nations Framework Convention on Climate Change 1998; and the United Nations Paris Agreement 2015.
[49] United Nations Framework Convention on Climate Change (UNFCCC) (1992) art 4(3)
[50] Ibid, article 4(5).
[51] See the United Nations Paris Agreement 2015, article 9.
[52] ODA refers to financial resources and other forms of foreign aid given by more developed countries to support development in developing countries.
[53] On the relationship between the Kyoto Protocol, which established the CDM, and the Paris Agreement, see further Muinzer, Thomas L Muinzer, 'What Do We Mean When We Talk About "Climate Change Acts" and How Important Are They in the Context of International Climate Law?' in Thomas L Muinzer (ed), *National Climate Change Acts: The Emergence, Form and Nature of National Framework Climate Legislation* (Bloomsbury-Hart 2020) 11–42.
[54] United Nations, 'The Clean Development Mechanism' https://unfccc.int/process-and-meetings/the-kyoto-protocol/mechanisms-under-the-kyoto-protocol/the-clean-development-mechanism accessed 9 June 2024.

countries in complying with their stipulated emission limitation and reduction commitments.[55] Hence, since the CDM is aimed at assisting developed countries in meeting their Kyoto targets through the financing of carbon emission reduction projects in developing countries, developing countries may obtain funding for the implementation of CCS projects in their jurisdictions under a CDM project.

iii. Corporate Funding

Various important and comprehensive aspects of the global partnership and cooperation for sustainable development initiatives are to a large extent within the purview of business and industry.[56] This is because business and industry can and do play a major role in the realization of sustainable development through the deployment of more efficient production processes, preventive strategies, and cleaner production technologies and procedures, throughout product lifecycles.[57] Hence, business and industry are encouraged to aim for an increase in the efficiency of resource utilization, including increases in the reuse and recycling of residues and reduction in the quantity of waste discharge per unit of economic output.[58] Pursuant to such corporate sustainability expectations, carbon-intensive businesses and industries in developing countries may be required to deploy some percentage of their financial resources towards financing cleaner production technologies and procedures such as CCS. To encourage and ensure this, governments of developing countries may need to identify and implement a mix of economic instruments such as tax incentives, capital grants, interest rate subsidies, and normative measures such primary law/legislation and formal standards for the promotion of the deployment of clean technologies.[59] This provides both a legal and business case for the financing of such technologies by business and industry.

iv. Sustainable Finance

The private sector can play a significant role in the alleviation of the financing constraints for sustainable development in developing and least developed countries across the world. As succinctly captured by the United Nations, sustainable development solutions can be found in unlocking the transformative potential of the private sector and incentivizing changes in financing patterns.[60] As a complement to public finance and other financing tools, the private sector, especially financial institutions and other institutional investors, may adopt sustainable practices that foster long-term value such as sustainable investment and finance, impact investing, responsible investing, etc. This may involve a reallocation of a percentage of assets under management towards long-term quality investment in sustainable development

[55] Kyoto Protocol (1998) art 12.
[56] United Nations, *Agenda 21* (1992) para 30.2.
[57] Ibid.
[58] Ibid, para 30.6.
[59] Ibid, para 30.8.
[60] See the "Addis Ababa Action Agenda" op cit., para 5. See also "The Future We Want" op cit., para 268.

projects such as CCS projects.[61] This may also involve the development of financial instruments to channel the financial resources of long-term investors to sustainable development, such as infrastructure investment, green bonds, etc. Financial institutions and other institutional investors can also provide both concessional and non-concessional long-term development finance by leveraging capital and mobilizing resources from capital markets.[62] For instance, special purpose vehicles may be used to consolidate a pool of private capital for investment in the development of carbon technologies and other CCS infrastructure.[63]

This may, however, entail that governments of developing countries implement a system that incentivizes the adoption of such sustainable investment strategies by financial institutions and other institutional investors. Such an incentive system may include the re-interpretation of the fiduciary duty of financial institutions and other institutional investors taking into consideration all factors that materially impact investment returns, including environmental, social and governance (ESG) issues. It may also include the promotion of sustainable corporate practices in the financial sector, such as the requirement to integrate ESG factors into financial reports and other statutory corporate reports. In addition, such an incentive system may involve the implementation of a carrot and stick regulatory system, which may take the form of tax subsidies, tax breaks, or tax waivers (etc.) for financial institutions and institutional investors engaging in sustainable investment on one hand, and an extension of the liability for ESG risks to financial institutions and other institutional investors that invest in unsustainable projects on the other hand.

Moreover, regarding climate change specifically, national governments must implement approaches that address existing barriers and accelerate the alignment of private financial flows with climate goals. For instance, national governments may need to address the knowledge gaps with regard to climate risk analysis in order to drive more appropriate climate risk assessment and efficient capital allocation. In other words, the potential adverse effect of climate change on the value of financial assets must be identified and understood so as to ascertain a business case for private sector investment in the low-carbon transition, including in relation to carbon technologies such as CCS.[64]

v. Innovative Climate Finance

The United Nations recognizes the deployment of innovative public and private financing mechanisms as a viable strategy for financing sustainable development

[61] United Nations Economic and Social Council, *Follow-Up and Review of the Financing for Development Outcomes and the Means of Implementation of the 2030 Agenda for Sustainable Development* (2018) para 14.

[62] United Nations, *Addis Ababa Action Agenda of the Third International Conference on Financing for Development* (27 July 2015).

[63] Ibid, para 50.

[64] Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2022: Mitigation of Climate Change – Working Group III Contribution to the Sixth Assessment Report* (2022) 1580.

projects.[65] According to the United Nations, such innovative financing mechanisms can assist developing countries in the mobilization of additional resources for financing sustainable development.[66] Such innovative finance mechanisms capable of supporting climate finance flows to developing countries include economic and fiscal incentives such as implementation of carbon taxes and emissions trading systems, employment of long-term green bonds from domestic capital markets, as well as public research and development funding for low-carbon technologies (etc.).[67] The system of carbon pricing through emissions trading, for instance, may be utilized as an additional financial resource for financing CCS projects in developing countries. For example, carbon credits and carbon bonds may be traded by governments for both public and private organizations to purchase in order to offset their carbon emissions. Such emissions trading schemes can assist in providing a stable source of finance for implementing CCS and other climate projects in developing countries.

The provision of public guarantees by national governments may also enhance investment by the private sector in the development of carbon technologies such as CCS.[68] This is more so with regard to green bonds and other loan instruments, as the provision of public guarantees reduces the exposure of private investors to credit risks. In other words, the provision of public guarantees by national governments contributes to the de-risking of private investments in such evolving climate technologies. Further, blended finance mechanisms which combine concessional public finance with non-concessional private finance, as well as non-recourse finance whereby creditors are entitled to repayment from the profits accrued from the development of CCS technologies and infrastructure, may be viable for the development of CCS projects in developing countries.[69]

4. FINANCING CCS IN THE GLOBAL SOUTH: SNAPSHOTS OF PRACTICE IN SELECTED COUNTRIES IN THE GLOBAL NORTH

In order to address the financial challenges associated with CCS deployment, and promote attractive CCS initiatives in the Global South, it is useful to consider some relevant initiatives and practices from the Global North. For instance, the Malaysian Government in 2023 introduced a tax incentive proposal for establishing CCS companies in Malaysia to limit CO_2 emissions to ensure the Low Carbon Nation Aspiration by 2040. The proposed tax incentive ensures in-house CCS companies receive: a 100% tax allowance for 10 years; full import duty and sales tax exemption on

[65] 'Agenda 21' op cit., para 33.16.
[66] *The Future We Want* (n 7) para 267.
[67] Intergovernmental Panel on Climate Change, "Climate Change 2022: Mitigation of Climate Change" op cit., p 1588 & 1599.
[68] Ibid, p 1586.
[69] See the "Addis Ababa Action Agenda" op cit., para 50.

the equipment used for CCS technology from 2023 to 2027; tax deduction for pre-commencement expenses within 5 years from the start of operations; a 70% tax exemption on statutory income for 10 years; and a tax deduction for service fees incurred.[70]

In a similar development, the Canadian Parliament introduced an investment tax credit for capital invested in CCUS projects in Canada in 2021. The policy provides for an 8-year period from 2022 to 2030, offering a refundable investment tax credit of up to 60% on capture equipment using direct ambient air, 50% on other capture equipment, and 37.5% on qualified carbon transportation, storage or usage equipment.[71] Similarly, the United States passed the Inflation Reduction Act of 2022, under which section 45Q incentivizes companies to invest in CCUS. Section 45Q encourages CCUS projects and stimulates further investment in the sector in relation to new projects, and it is estimated to help decarbonize power and industrial plants in the country. The cost of the credit for the US government is estimated to be $2.3 billion for 2020-2029. The structure provides two crediting mechanisms, the first being capture credits, awarded for each ton of CO2 that is securely stored, and the second being sequestration credits, for the proper capture and utilization of captured CO_2 for commercial purposes. In 2022 the monetary credit was updated to $85/t CO2 for carbon capture and geologic storage (CCS) and $60/t CO2 for carbon capture and storage via utilization (CCUS) including enhanced oil recovery (EOR).

5. LESSONS LEARNED AND RECOMMENDATIONS

It is evident that for emerging economies, achieving the net zero goal and establishing renewable projects requires a large amount of financial assistance as well as proper infrastructure to achieve these goals. Specifically, where the implementation of CCS projects are under consideration, this entails various activities ranging from the building and operation of capture infrastructure, to the building of transportation pipelines and secure storage facilities, which are generally expensive and require high upfront investment expenditure. This is in addition to the energy requirements of carbon capture and compression, which increase the overall associated costs of CCS projects.[72] Although high capital costs for CCS development and deployment are generally

[70] https://belanjawan.mof.gov.my//pdf/belanjawan2023/ucapan/tax-measure.pdf

[71]https://distribution-a617274656661637473.pbo-dpb.ca/8e95e1ac78923bcec809e769bbe39a85e5258ad4582499199a27ab26687f8627

[72]DBRS Morningstar, 'High Investment Costs and Untested Technology Are Challenges for the Carbon Capture Industry' (10 October 2023) https://dbrs.morningstar.com/research/421543/high-investment-costs-and-untested-technology-are-challenges-for-the-carbon-capture-industry accessed 10 June 2024; see also CECO Environmental, 'Barriers to Successfully Implementing Carbon Capture, Utilization, and Storage (CCUS)' (25 April 2024) https://www.cecoenviro.com/barriers-to-successfully-implementing-carbon-capture-utilization-and-storage-ccus/ accessed 10 June 2024.

applicable, this is particularly relevant to developing and least developed countries, considering the level of their technological advancement and the financial resources available to them in comparison with developed countries.

We must acknowledge that the Global South, under the UNFCCC's acknowledgment of common but differentiated responsibilities, is granted a period of grace in the achievement of CO_2 emissions reduction. During this period of grace, it is recommended that countries in the Global South seeking to accelerate the deployment of CCS should properly and thoroughly review financial instruments in practice today. Opportunities pertaining to CCS as its effectiveness can be maximized through policy coherence, certainty and organizational/international collaboration. Furthermore, regulators/policy drafters seeking to enforce financial instruments should draft these on both a country-by-country basis, and based upon evaluation of a country's local context while ensuring measures are proportional to the purpose.[73]

In addition to the available financial instruments countries in the Global South can consider, several international instruments on climate change recognise the need for countries with more financial resources, particularly developed countries, to financially assist developing and least developed countries, who are more vulnerable to climate change and less financially endowed, in implementing their climate obligations.[74] According to the UNFCCC, developed country-parties are required to provide financial resources to meet the agreed full costs incurred by developing countries in complying with their climate commitments and obligations under the Convention.[75] Such developed countries are also vested with the responsibility to adopt practicable steps to promote, facilitate and finance access to, or the transfer of, environmentally sound technologies to developing country-parties.[76] Likewise, pursuant to the Paris Agreement, developed countries that are party to the UNFCCC have the responsibility to provide financial resources to assist developing country-parties with respect to their climate commitments.[77] Hence, various sources of international public finance that could be harnessed by developing countries for the funding of sustainable development projects such as CCS include: FDIs, ODAs,[78] export credits or other financial instruments from international financial institutions, etc. The CDM established originally under the Kyoto Protocol can also play a significant role in this regard.

[73] C-580/14 (n 83).
[74] See for instance, the United Nations Framework Convention on Climate Change 1992, and the Kyoto Protocol to the United Nations Framework Convention on Climate Change 1998; and the United Nations Paris Agreement 2015.
[75] The United Nations Framework Convention on Climate Change 1992, article 4(3).
[76] Ibid, article 4(5).
[77] See the United Nations Paris Agreement 2015, article 9.
[78] ODA refers to financial resources and other forms of foreign aid given by more developed countries to support development in developing countries.

6. CONCLUSION

The aim to meet the global climate challenge can be viewed from a dual perspective, one from the perspective of the global north and the other from the global south. The endeavour to achieve the target can be referenced against the per capita income of countries. The per capita income in sub-saharan Africa is estimated to be less than $1,800, and $2,900 in India. Compared to the per capita income of North America ($63,000) and Western Europe ($51,000), the difference in the per capita income between the global north and global south provides a sense of capacity in relation to the two spheres and their ability to transition into sustainable energy and adopt CCUS structures. Developed countries have introduced various financial incentives and subsidies to assist the establishment of structures such as CCS within their systems for a cleaner form of transition and control of GHG emissions.

Depending on the chosen instrument/s, overall, it is clear that by drawing on global experiences and best practices, and evaluating a country's local context, policymakers in collaboration with stakeholders can encourage enhanced policy coherence, regulatory certainty and organizational and international collaboration to bolster a more effective role for financial instruments towards accelerating CCS deployment and ultimately contributing to Net Zero targets as mandated under the Paris Agreement.

Essentially being infrastructure focused, the energy sector demands a strong and well established infrastructure; however, due to the affordability of fossil fuel energy in comparison to a high initial capital with large-scale connections (pipelines), CCS projects can be more complex and more costly for developing countries, which connects in turn to challenges in attracting capital and securing favourable financial conditions, which can prove tougher for developing low GDP countries in an already high interest rate environment.

There must be a general understanding that the Global South must be allowed flexibility in its energy transition, to first establish its energy security by ensuring its affordability and accessibility, then by moving onto more ambitious goals of establishing native structures to introducing renewable energy into the energy production and consumption mix. To achieve these layered goals for the Global South, a North-South collaboration is essential and a focus on a flexible set of financing structures with international financial bodies will provide valuable assistance. CCS structures have a potential to allowing developing countries to continue their reliance on fossil fuels for a temporary period without creating major emissions, but this requires the establishment of adequate financial and technological collaboration between the Global North and the South.