STI FORUM

Science, Technology & Innovation for the Sustainable Development Goals

Seventh annual Multi-stakeholder Forum on Science, Technology and Innovation for the Sustainable Development Goals

Thematic Session 5: Emerging Carbon Dioxide Removal Technologies for Addressing Climate Change

(15:00-16:00 EST, 6 May 2022)

Background

The Intergovernmental Panel on Climate Change (IPCC) was jointly established by the World Meteorological Organization and the United Nations Environment Programme in 1988. Its terms of reference include: (i) to assess available scientific and socio-economic information on climate change and its impacts and on the options for mitigating climate change and adapting to it and (ii) to provide, on request, scientific/technical/socio-economic advice to the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC). From 1990, the IPCC has produced a series of Assessment Reports (AR), Special Reports, Technical Papers, methodologies and other products that have become standard works of reference, widely used by policymakers, scientists and other experts.

At COP7, a draft decision was taken to invite the IPCC to write a technical paper on geological storage of carbon dioxide. In response to that, at its 20th session in 2003 in Paris, France, the IPCC agreed on the development of the Special Report in 2005[1] on Carbon dioxide Capture and Storage as an option for mitigation of climate change.

In 2013-2014, the IPCC's Fifth Assessment Report[2] provided the scientific input into the Paris Agreement, which aims to strengthen the global response to the threat of climate change by holding the increase in the global average temperature 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.

Many countries considered that a level of global warming close to 2°C would not be safe and, at that time, there was only limited knowledge about the implications of a level of 1.5°C of warming for climate-related risks and in terms of the scale of mitigation ambition and its feasibility. Parties to the Paris Agreement therefore invited the IPCC to assess the impacts of global warming of 1.5°C above pre-industrial levels and the related emissions pathways that would achieve this enhanced global ambition.

At the start of the Sixth Assessment cycle, governments, in a plenary IPCC session, decided to prepare three special reports, including one published in 2018 on achieving a target of 1.5°C [3], and expanded its scope by framing the assessment in the context of sustainable development and efforts to eradicate poverty. The Special Report found clear benefits to keeping warming to 1.5°C rather than 2°C or higher, and that limiting warming to 1.5°C can go hand in hand with achieving other global goals such as the Sustainable Development Agenda.

This 1.5° Special Report also showed that recent trends in emissions and the level of international ambition indicated by nationally determined contributions (NDCs), within the Paris Agreement, deviate from a track consistent with limiting warming to well below 2°C. The NDCs did not for the most part include carbon dioxide removal (CDR) technologies in their plans. Without increased and urgent mitigation ambition in the coming years, leading to a sharp decline in greenhouse gas emissions by 2030, global warming will surpass 1.5°C in the following decades, leading to irreversible loss of the most fragile ecosystems, and crises for the most vulnerable people and societies. In the context of systemic transitions across energy, land, urban and industrial systems, the Special Report assesses adaptation and mitigation options, including carbon dioxide removal (CDR) measures, as well as the enabling conditions that would facilitate implementing the rapid and far-reaching global response.

In the context of 1.5°C-consistent pathways, CDR measures serve to offset residual emissions and, in most cases, achieve net negative emissions to return to 1.5°C from an overshoot. Over the last decade the scientific community has considered the possibility of using CDR Technologies such as direct air carbon capture and storage (DACCS) or Bioenergy with carbon capture and storage (BECCS) as emissions mitigation mechanisms and these technologies are currently in practice at small (single industrial plant) scale. The 2018 Special Report assesses from an extensive literature review the abatement costs, potential for $GtCO^2$ removal per year and side effects by 2050, as well as cross cutting issues and uncertainties for the most studied BECCS and DACCS, as well as a number of proposed emerging CDR technologies. Over half of the literature on these technologies is in the early stage – modeling or small lab study.

In the last five years there has been keen interest in emerging CDR technologies, National Academies studies, national field demonstrations, extensive reviews, both government and NGO funders and companies formed to do field demonstrations and scale up. Corporations are incorporating CDR technologies into their plans. The Working Group III's contribution to the 6th Assessment Report (AR6) published in April 2022 assesses the utilization of a range of emerging negative emissions technologies such as nature-based solutions like afforestation and soil enhancement, both for climate mitigation and adaptation, in synergy with mitigating biodiversity loss. Many different CDR technologies are being explored and are already contained in over 100 updated NDCs.

The various choices of CGR technologies that will actually be deployed in the coming years will have different implications for the achievement of other SDGs, in particular SDG14 on oceans and SDG15 on terrestrial ecosystems.

Indicative implications for oceans (SDG14)

The ocean plays a major role in buffering the global climate system by capturing and storing CO_2 away from the atmosphere. It acts globally as a net sink for anthropogenic CO_2 and significantly reduces the rate of global warming. The organic carbon that is captured and stored by the ocean is often referred to as "blue carbon". Coastal vegetated ecosystems (CVE), such as seagrass meadows, tidal marshes and mangrove forests accumulate and store large stocks of organic carbon in their sediment, with rates of burial per hectare that are estimated to be an order of magnitude greater than those of terrestrial forests. Therefore, they are considered major players in nature-based solutions to climate change adaption strategies. In addition, the current magnitude of sedimentary carbon losses resulting from widespread habitat degradation calls for coordinated actions to create and restore habitats and to implement creative eco-engineering solutions.

While a number of studies have been conducted on blue carbon in CVE during the last decade, many questions still remain unanswered. These encompass aspects such as: the evaluation of global hotspots that are largely understudied (i.e. Central and South America, Asia); how climate change and other disturbances will impact blue carbon systems; the role of macroalgae and seaweed farming; or the best management actions to maintain and enhance carbon sequestration in blue carbon habitats. Also, advancing the scientific understanding of impacts of proposed large-scale farming and sinking seaweed in the oceans is imperative.

The evaluation of the capacity of coastal ecosystems or seaweed farming to sequester carbon from atmospheric CO2, (as Blue Carbon), is done using nuclear technologies (C14 dating, estimation of carbon fluxes with isotopic ratios, etc). The assessment of carbon stocks in CVE is done by measuring its contents (and those of other parameters such as N, for instance) by mass spectrometry (various methods depending on whether elemental or isotopic determinations). Rates of sequestration in the soils are established using radioactive tracers, such as Pb-210 and Cs-137 at decadal/century scale and C-14 at century/millennia. Methods for these include radiometric counting and mass spectrometry.

Implications for terrestrial ecosystems (SDG15)

Agricultural production plays a key role in climate change, which underlines the need to reduce greenhouse gas (GHG) emissions and to increase carbon sequestration in soil. The high variability of C footprints across different types of agricultural products, pedoclimatic conditions and management practices implies that climate change mitigation measures in agriculture shall be tailored to each specific situation. Agricultural production is responsible of direct emissions of GHG, such as N2O, from synthetic and organic N fertilization, and CH4 from rice paddies. However, indirect emissions taking place outside the agroecosystem also play a key role. These indirect emissions can be classified as upstream, i.e. due to the production of agricultural inputs, such as fertilizer manufacture, and downstream, which include N2O emissions from N compounds escaping the farm, i.e. from ammonia deposition and nitrate leaching. In addition, soil and biomass C sequestration can have a major role in the GHG budget of agroecosystems.

The life cycle assessment methodology allows the integrated assessment of all these components of the GHG budget in a an internationally standardized but methodologically flexible way, expressing the resulting C footprint per unit hectare or per unit product, and thus allowing the comparison between different systems. However, different methodologies are being applied to calculate C footprints, which often make it difficult to compare the results from different studies. In this work, we aimed to develop a robust C footprint calculation tool using novel methods to estimate different components of the GHG emission budget of major crop types across global agroecosystems. The on-going work has been developed in an international framework supported by the IAEA-FAO and coordinated by CEIGRAM-UPM with the close collaboration of researchers from Asia, Africa, Europe and Latin America.

Contextual framework

In this context, the role of CDR or Negative Emission Technologies, both terrestrial and ocean-based, for climate mitigation and adaptation is emerging and already in the future plans for nations and current near-term plans for corporations, yet many uncertainties remain and must be addressed.

The ability to scale up these technologies fast enough to remove sufficient emissions given the current state of global mitigation is not clear, CDR that does not use geological reservoirs are short term storage and can be reversed to become sources rather than sinks, and there are a number of ethical and governance issues, potential land and ocean shelf use conflicts and potential side effects and unintended consequences of their use at a local, national and corporate level.

Objectives and likely key messages

To address the unknowns and uncertainties and risks of using these CDR technologies as they are going into more widespread use, the STI Forum should convene an ongoing open discussion with all international stakeholders on the research and demonstrations needed to better understand potential consequences, costs and trade-offs of various technologies, their interactions with various SDG goals, and their ethical and governance issues alongside conventional mitigation and adaptation strategies. There are already collaboration networks on specific technologies. This would be a network of networks.

It could also explore how to establish a global system that effectively guides communities of practice in an articulated, collaborative, informative and systemic manner, providing online and in-person forums for discussion and data on the TFM website, guiding best practices in the deployment of CDR and knowledge gained from deployments. This could be linked to inform and dialog with the Partnership in Action STI4SDG roadmaps.

Similarly, the STI Forum could consider how, in the spirit of SDG 17, to attract and coordinate existing research funds, NGOs, national and international aid organisations, national development banks and other public or private funds, to generate and fund the research, development and deployment of the most promising CDR technologies for particular actors and regions alongside conventional mitigation and adaptation strategies along with synergies and trade-offs for various SDG goals (food, water, life on land, life under water, clean energy, equity, decent jobs.)

Format

Thematic session 2 will address the growing need for CDR technologies, what they are, the proposals and deployments of various technologies worldwide and our state of knowledge about these technologies. It will consist of a moderator and a panel of stakeholders, who will provide brief video presentations ahead of time and then engage in a general discussion during the panel.

Speakers will be invited who are authors of authoritative reviews of the technologies who can speak to knowledge gaps, CEOs and CTO's of CDR companies, funders of research in CDRs, already existing international research and deployment communities of practice and ministers of nations or CEOs of industrial companies either deploying or having plans to deploy these technologies.

Speakers will highlight good practices in policy and governance at global regional and national levels, including a range of interactions with other SDGs.

Guiding questions

The discussion will be guided by the following questions:

- CDR technologies are needed at the local (industrial or power plant), national (NDC), and global scale (reaching net zero global emissions). What partnerships are best at each level?
- For companies and funders– how do you plan to scale up your technologies to make a difference at the global scale of 1-10Gt/yr?
- How can we better support the innovation ecosystem around these technologies?

- How can the UN contribute to a showcase of emerging demonstration projects and best deployment practices of CDR technologies?
- How can the UN contribute to a responsible discussion of the potential consequences, costs and trade-offs of various technologies, their interactions with various SDG goals, and their ethical and governance issues alongside conventional mitigation and adaptation strategies?

Supporting documents/publications

1. IPCC (2022). *Climate Change 2022: Mitigation of Climate Change*, Working Group III contribution to the 6th Assessment Report of the IPCC, April 2022, https://www.ipcc.ch/report/ar6/wg3/
2. Jan C Minx et al. (2018). Negative emissions—Part 1: Research landscape and synthesis, Environ. Res. Lett. 13 063001, https://iopscience.iop.org/article/10.1088/1748-9326/aabf9b
3. Sabine Fuss et al. (2018). Negative emissions—Part 2: Costs, potentials and side effects, Environ. Res. Lett. 13 063002, https://iopscience.iop.org/article/10.1088/1748-9326/aabf9f
4. Gregory F Nemet *et al* (2018). Negative emissions—Part 3: Innovation and upscaling. *Environ. Res. Lett.* **13** 063003, https://iopscience.iop.org/article/10.1088/1748-9326/aabff4
5. National Academies of Sciences, Engineering, and Medicine. 2022. A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration. Washington, DC: The National Academies Press. https://doi.org/10.17226/26278, https://www.nationalacademies.org/our-work/a-research-strategy-for-ocean-carbon-dioxide-removal-and-sequestration
6. IPCC (2005). *Carbon Dioxide Capture and Storage*, A Special Report of Working Group III
7. of the Intergovernmental Panel on Climate Change, https://www.ipcc.ch/report/carbon-dioxide-capture-and-storage/
8. IPCC (2014): *Climate Change 2014*, 5th Assessment Report, https://www.ipcc.ch/assessment-report/ar5/