THE STATE OF Carbon Dioxide Removal

The State of Carbon Dioxide Removal report is cited in the information note titled "Removal activities under the Article 6.4 mechanism" version 4, available at: https://unfccc.int/sites/default/files/resource/a64-sb005-aa-a09.pdf. As organizers and lead authors of the report, we are concerned about how the report is used to support arguments in the information note, the taxonomy of CDR methods applied as well as a favourable portrayal of land-based CDR activities in contrast to engineering-based activities. In our perception, this is not in line with the balance of evidence in the scientific literature. Our comments relate specifically to Table 3 in the note, copied below:

Activity type	Pros and cons
Engineering-based activities	**Pros** – Engineering-based removal activities result in permanent net removal of carbon dioxide from the atmosphere. **Cons** – Engineering-based removal activities are technologically and economically unproven, especially at scale, and pose unknown environmental and social risks (P-12, R-83:a, R-84:a, R-50:c,d). Currently these activities account for removals equivalent to 0.01 $MtCO_2$ per year (P15:a) compared to 2,000 $MtCO_2$ per year removed by land-based activities. – These activities do not contribute to sustainable development, are not suitable for implementation in the developing countries and do not contribute to reducing the global mitigation costs, and therefore do not serve any of the objectives of the Article 6.4 mechanism.
Land-based activities	**Pros** – Land-based activities are proven and safe, have a long history of practice, and are backed by considerable experience under compliance and voluntary carbon market mechanisms. – Land-based activities have the potential to the deliver cost-effective CO_2 mitigation required by 2030, a third of which could be below USD 10 per tCO_2. – Land-based activities generate significant sustainable development co-benefits (P-26:b,R-80): – Economic: increased availability of wood and non-wood products including wood fuels and livestock feed; improved crop yields through soil erosion control, soil fertility improvement, groundwater recharge, water filtration, water quality); sustainable and equitable local employment and livelihoods. – Environmental: biodiversity conservation, reduced air pollution, reduced pressure on natural forests, flood control, and enhanced climate resilience. – Socio-cultural: space for socio-cultural events, nature contemplation, aesthetic appreciation, creativity and learning, recreation, and ecotourism.

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	Cons – Removals stored in ecosystem reservoirs can be released back into the atmosphere, thus limiting their mitigation value.

About the State of Carbon Dioxide Removal[1]:

- An independent, comprehensive, reliable and transparent scientific assessment on the state of carbon dioxide removal;
  - Community-based research effort led by the University of Oxford, Mercator Research Institute on Global Commons and Climate Change (MCC), the International Institute for Applied Systems Analysis (IIASA), the German Institute for International and Security Affairs (SWP) as well as the University of Wisconsin-Madison.

Key Findings of the report:

- Calculated current CDR deployments at 2± 0.9 $GtCO_2$/yr (mainly afforestation and reforestation), with only 0.002 $GtCO_2$/yr from novel CDR methods (mainly BECCS and biochar);
- Quantified a sizable gap between CDR proposed by countries and CDR observed in mitigation scenarios consistent with limiting warming to well below 2°C in the short-term (2030) as well as the long-term (2050);
- Highlighted the urgency to develop and deploy a portfolio of CDR methods such as forestry, bioenergy with carbon capture and storage (BECCS), enhanced weathering, biochar, direct air carbon capture and storage (DACCS) among others over the next 10 years to close the gap. Particular attention should be given to the development of novel CDR methods due to their early stage deployment and lower TRL levels.

Comments:

- Ref R-50 (the State of CDR report[1]) does not support the statement that engineering-based activities are technologically unproven and have unknown risks. Instead, Table 1.1 in the State of CDR report provides an expert assessment of Technology Readiness Levels, and known risks as well as co-benefits, for these methods, based on the literature. The data in this table matches that in Table 4 of the Information note, because it is drawn from the same source (IPCC AR6 WGIII[2]). We recommend that the data in Table 4 is used to reflect more accurately the variations across methods, rather than the over-generalised and inaccurate statement in Table 3.
- The taxonomical differentiation between engineering-based and land-based methods is inconsistent across the information note. While BECCS is classified as an engineering-based method in Table 4 in the information note, it is classified as a land-based removal activity in appendix H. The conclusions drawn would change considerably based on where BECCS is categorized. We therefore urge to be transparent and consistent in the taxonomy of CDR applied across the document. Moreover, we believe that the distinction between engineering-based CDR approaches and land-based CDR approaches it is not particularly purposeful for discussing the

[1] Smith, S.M., et al. (2023) The State of Carbon Dioxide Removal - 1st Edition. The State of Carbon Dioxide Removal. doi:10.17605/OSF.IO/W3B4Z

"pros" and "cons" of different groups of CDR methods. For this very reason such a distinction was avoided in the most recent IPCC 6th Assessment report[2] and the State of CDR report[1]. For a policy-relevant classification of CDR we recommend to consider the technological readiness level (TRL) as well as our ability to monitor, report and verify (MRV) removals from a particular CDR method.

- The Note omits the significant complexity and uncertainty of MRV of emissions (and removals) of land-based activities. We highlight one specific concern among many from the literature (see, e.g., Box 1 of the cited manuscript)[3]: "*[the] UNFCCC explicitly asks countries to report a value of carbon flux, providing default methods and factors that can be used despite the underlying paucity of national data*." We strongly suggest including difficulty of MRV as a "con" for Land-based methods. This is underlined by the large uncertainty range for assessments of current land-based removals (evaluated as ±45% in the State of CDR report[1]) as well as the large uncertainty range for assessments of the broader land use flux (evaluated as ±70% in IPCC 6th Assessment Working Group III report[4]).
- The State of CDR report[1] provides the only comprehensive estimate of current CDR deployment to our knowledge and should be referenced in this context. Related to the taxonomical inconsistencies in the information note, the 0.01 $MtCO_2$ per year of current removals cited in P15:a refers to Direct Air Capture only, not all "engineering-based" methods. Adding removals from BECCS in alignment with Table 4 provides a more complete estimate of around 1.8 $MtCO_2$ per year (this differs from the 2 $MtCO_2$ per year reported in the State of CDR for all "novel" activities because it subtracts the estimate for biochar, which is not defined as "engineering-based" in this Information note).
- Furthermore, the statement that land-based activities currently remove 2,000 $MtCO_2$ per year is currently unattributed, but can be drawn from the State of CDR report, which provides an estimate of 2,000 ± 900 $MtCO_2$ per year.
- The statement that engineering-based removals do not contribute to sustainable development is inaccurate, based on the Information note's own data in Appendix I. This Appendix gives explicit alignment to Sustainable Development Goals for some activities; for instance, some forms of DACCS supporting SDG6, and enhanced rock weathering supporting SDGs 2, 15, 14 & 6. The statement also does not clarify that contributions to the SDGs - and conversely, social and environmental risks - are conditional on the scale and means of implementation, where appropriate governance and efforts to secure procedural and distributive justice are key. This is the case for both engineering-based and land-based technologies, as well as for climate mitigation policies in general, as highlighted in the IPCC 6th Assessment Working Group III report[4].
- The statement in Table 3 that these removals do not contribute to global mitigation costs is inaccurate. Of all modelled pathways that limit warming to 2°C with a likelihood of 66% or lower

[2] Babiker, M. et al. 2022. 'Chapter 12: Cross-Sectoral Perspectives'. In Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, edited by P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, et al. Cambridge, UK and New York, NY, USA: Cambridge University Press (CUP). 10.1017/9781009157926.005.

[3] Grassi, G., et al. (2022).: Carbon fluxes from land 2000–2020: bringing clarity to countries' reporting, Earth Syst. Sci. Data, 14, 4643–4666, https://doi.org/10.5194/essd-14-4643-2022.

[4] IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, et al., (eds.)]. doi: 10.1017/9781009157926.001

(C1, C2, and C3 IPCC scenario categories), 93% include BECCS while 27% include DACCS "engineering-based" removals as well as "land-based" ones[5]. The IPCC states: "*Modelled mitigation strategies to achieve these reductions include transitioning from fossil fuels without CCS to very low- or zero-carbon energy sources, such as renewables or fossil fuels with CCS, demand side measures and improving efficiency, reducing non-CO_2 emissions, and deploying carbon dioxide removal (CDR) methods to counterbalance residual GHG emissions.*"[6]

- In contrast, the State of CDR report[1] highlights the importance of "engineered-based" CDR in the vast majority of Paris-relevant mitigation scenarios as assessed by the Intergovernmental Panel on Climate Change. Figure 7.1 in the State of CDR highlights the limited potential of "land-based" CDR methods to provide the required quantities of removals frequently observed in Paris-relevant scenarios on their own and the need to complement these with additional engineered-based CDR. Overall, the report underlines the importance of developing and deploying "engineered-based" CDR methods to keep the Paris climate goals within reach.
- Finally, we would like to point out that there are risks associated with the large-scale deployment of land-based CDR methods widely discussed in the peer-reviewed scientific literature[7,8] as well as the State of CDR report[1] and the most recent IPCC assessment[2] such as threats to biodiversity, food security or water scarcity that are not reflected as "cons" in Table 3 of the information note. Sustainability implications of land-based CDR methods can be positive or negative depending on, for example, the implementation practices, the scale of biomass sourcing and other pressures on land. We recommend either complementing the current "pros" of land-based CDR methods in Table 3 associated with sustainable land and biomass use with the "cons" associated with unsustainable practices that are also possible, or to simply highlight the potentially positive or negative implications of land-based CDR methods depending on biomass source and level, implementation practices, geographical context and the degree of land competition among others.

In summary, we recommend that individual "engineering-based" CDR activities should be made eligible for Article 6.4, subject to them meeting the requirements regarding monitoring, reporting, accounting, addressing of reversals, avoidance of leakage and avoidance of other negative impacts, as set out in the document. This should be the approach rather than a blanket inclusion or exclusion of activities as a result of being labelled "engineering-based."

We hope that our comments are constructive and helpful.

Warm regards,

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[5] See footnote 1: Smith et al. (2023), Table 7.2.

[6] IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, et al., (eds.)]. doi: 10.1017/9781009157926.001

[7] Minx, Jan C et al. 2018. 'Negative Emissions—Part 1: Research Landscape and Synthesis'. Environmental Research Letters 13 (6): 063001–063001. https://doi.org/10.1088/1748-9326/aabf9b

[8] Fuss, Sabine et al. 2018. 'Negative Emissions—Part 2: Costs, Potentials and Side Effects'. Environmental Research Letters 13 (6): 063002–063002. https://doi.org/10.1088/1748-9326/aabf9f