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Ocean-based Negative Emission Technologies

OCEAN NETs

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Abstract:
The sustainable development goals (SDGs) provide a comprehensive global plan of action for peace and prosperity for people and the planet. These ambitious SDG commitments require many actions to achieve and it is important that potential new activities, such as ocean-based carbon dioxide removal (CDR) as a means of climate change mitigation, do not hinder progress towards the SDGs. Here we describe a CDR SDG assessment framework that we developed for future use in evaluating the sustainability of different ocean-based CDR options or portfolios. The assessment methodology describes how the user should first collect relevant information about the CDR approach(es) and then match it to the corresponding SDG indicators or sub-indicators. After that the user must transform (normalize) the derived indicator data for comparability. Then, the user must follow several steps of weighting, aggregation, and evaluation that follow an SDG structured nesting approach. In the end the methodology allows the user to quantify CDR impacts on progress towards attaining overall "sustainability". No application of the framework was done as part of this task, but should be done in future research endeavors.

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Document History

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Disclaimer:

List of abbreviations, acronyms and definitions

Carbon Dioxide Removal (CDR)
Sustainable Development Goals (SDGs)
Composite Indicator (CI)

1. Introduction

1.1 Context

OceanNETs is a European Union project funded by the Commission's Horizon 2020 program under the topic of Negative emissions and land-use based mitigation assessment (LC-CLA-02-2019), coordinated by GEOMAR Helmholtz Centre for Ocean Research Kiel (GEOMAR), Germany.

OceanNETs responds to the societal need to rapidly provide a scientifically rigorous and comprehensive assessment of negative emission technologies (NETs). The project focuses on analyzing and quantifying the environmental, social, and political feasibility and impacts of ocean-based NETs. OceanNETs will close fundamental knowledge gaps on specific ocean-based NETs and provide more in-depth investigations of NETs that have already been suggested to have a high CDR potential, levels of sustainability, or potential co-benefits. It will identify to what extent, and how, ocean-based NETs can play a role in keeping climate change within the limits set by the Paris Agreement.

1.2 Purpose and scope of the deliverable

This deliverable is a product of WP7 *Stakeholder Dialogue and the Provision of Knowledge* task 7.7 *Develop a sustainable development goals framework for ocean-based NET evaluation*. The stated task is: "Information on the sustainable development goals and how these relate to activities surrounding ocean-based NETs will be acquired, analyzed, and used to develop a framework to evaluate when there are synergies between the SDGs and ocean-based NETs or when these NETs or specific levels/locations of NET deployment violate the SDGs. Interactions between SDGs will be considered in this analysis with an understanding that many SDGs are aspirational. The development of a framework for assessing ocean-based NETs in the context of the SDGs will be based on prior SDG assessment frameworks that were developed to evaluate new technologies and climate mitigation approaches."

As the OceanNETs project aims to provide a comprehensive assessment of ocean-based CDR and the basis for further future research, understanding how these approaches interact with the SDGs is important. Therefore, we proposed to develop an assessment framework that can be used to provide such an understanding. This legacy tool will be useful for the ocean CDR community and in future research endeavors beyond OceanNETs.

1.3 Relation to other deliverables

This is a stand-alone deliverable that draws upon expert knowledge from within the consortium. It will only be utilized in other deliverables involving stakeholders and policy briefings, as well as final synthesis products, where the development of the tool can be mentioned and promoted as a legacy product.

2. Technical part of the deliverable

2.1 Introduction

In 2015 all United Nations Member States adopted the 2030 Agenda for Sustainable Development (https://sdgs.un.org/2030agenda) —a comprehensive global plan of action for peace and prosperity for people and the planet.

The plan is comprised of 17 Sustainable Development Goals (SDGs) to be achieved by 2030:

1) No Poverty
2) Zero Hunger
3) Good Health and Well-being
4) Quality Education
5) Gender Equality
6) Clean Water and Sanitation
7) Affordable and Clean Energy
8) Decent Work and Economic Growth
9) Industry, Innovation and Infrastructure
10) Reducing Inequality
11) Sustainable Cities and Communities
12) Responsible Consumption and Production
13) Climate Action
14) Life Below Water
15) Life on Land
16) Peace, Justice, and Strong Institutions
17) Partnerships for the Goals

Each SDG has been further elaborated on by breaking it down into specific targets of which there are a total of 169 for the 2030 agenda. For example, **Goal 13** *Take urgent action to combat climate change and its impacts* has 5 targets: ***13.1*** *Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries,* ***13.2*** *Integrate climate change measures into national policies, strategies and planning,* ***13.3*** *Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning,* ***13.a*** *Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible,* and ***13.b*** *Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.*

Each target then has indicators associated with it to allow for the assessment of progress towards meeting the goal. For example, for **Target 13.2** (above) the indicators are: ***13.2.1*** *Number of countries with nationally determined contributions, long-term strategies, national adaptation plans and adaptation communications, as reported to the secretariat of the United Nations Framework Convention on Climate Change* and ***13.2.2*** *Total greenhouse gas emissions per year.*

These ambitious SDG commitments require many actions to achieve. Achievement is also not a straightforward task as there are various synergies and trade-offs between the SDGs (Horvath et al., 2022; Moallemi et al., 2022). Actions taken to mitigate climate change have already been shown to have direct and indirect interactions with development goals, that also involve both positive synergies and negative trade-offs (Moreno et al., 2023; Nerini et al., 2019). Here we focus on carbon dioxide removal (CDR), which is one action that has been recognized as necessary to mitigate climate change (IPCC, 2018, 2021, 2022). Few studies have evaluated how CDR may interact with all sustainable development goals (Honegger et al., 2020). Those that have mostly focused on land-based approaches, e.g., Smith et al., (2019b, 2019a), with the exception of Honegger et al., (2020), and have been limited to qualitative identifications of potential impacts on the SDGs rather than quantifying how they are or can help achieve all of them together. This is understandable as most CDR approaches are immature and have not been deployed at large scales, thus limiting the amount of data that is available for assessing interactions with the SDGs. However, there is a need to assess how the potential future deployment of different CDR approaches will help or hinder progress towards meeting all SDGs. Ideally, large-scale CDR deployments will be sustainable with respect to all SDGs, rather than helping attain SDG 13 (climate action) at the expense of other goals. If information on CDR sustainability can be determined, it will be especially useful to help set policies. That is, with a good assessment SDG enabling CDR approaches can be prioritized and SDG hindering approaches can be restricted via good policies.

In this study for the OceanNETs project we focus on how ocean-based CDR approach impacts can be quantitatively assessed from an SDG perspective. To do this we have developed an assessment framework methodology that builds upon prior SDG assessments of other actions (Rickels et al., 2016, 2019). While we outline the steps that need to be taken to do an assessment, applying the framework is beyond the scope of the project task described in this report.

2.2 Discussion of what is needed for a quantitative assessment of the SDGs with respect to ocean-based CDR actions

No SDG targets or indicators directly address or include ocean-based CDR as a means of climate change mitigation. However, this does not mean that potential future ocean-based CDR approaches could not contribute to meeting various SDGs through the wide variety of activities that would need to happen to enable large scale ocean-based CDR. Obviously CDR will contribute to SDG 13 (climate action). Ocean-based CDR will also have an impact on SDG14 (life below water). Other impacts are not as clear and likely often method specific. Honegger et al., (2020) made a first attempt to identify interactions between the SDGs and ocean alkalinization and ocean fertilization with an assessment of whether interactions at the SDG level (i.e., the overall goal level, not the target or indicator levels) would be positive, negative, or potentially both. While they did identify where potential interactions with the SDGs could occur, their analysis could not identify the overall sustainability of these approaches in a quantitative manner. They concluded that specific impacts can only be judged in the context of specific local circumstances and that case-specific learning is needed for a full SDG evaluation. Here we describe how to do a quantitative assessment of the SDGs with respect to ocean-based CDR actions.

A quantitative ocean-based CDR SDG assessment requires multiple steps to be completed. This includes collecting the relevant information about the CDR approach(es) and then matching it to the corresponding SDG indicators. For immature CDR options this may also involve developing future deployment scenarios or case studies that include estimated potential impacts. After that the indicators must be transformed (normalized) for comparability. Then, several steps of weighting, aggregation, and evaluation are needed, for which a nesting approach is useful (Fig. 1). The SDG framework with its assignment of indicators to targets provides a clear proposal for the nesting structure, having first an indicator (or sub-indicator) level, second a target level, third an SDG level, and fourth an overall sustainability level. The second, third, and fourth levels can be assessed by means of a composite indicator (CI) approach that follows the methodology of Rickels et al., (2014, 2016, 2019).

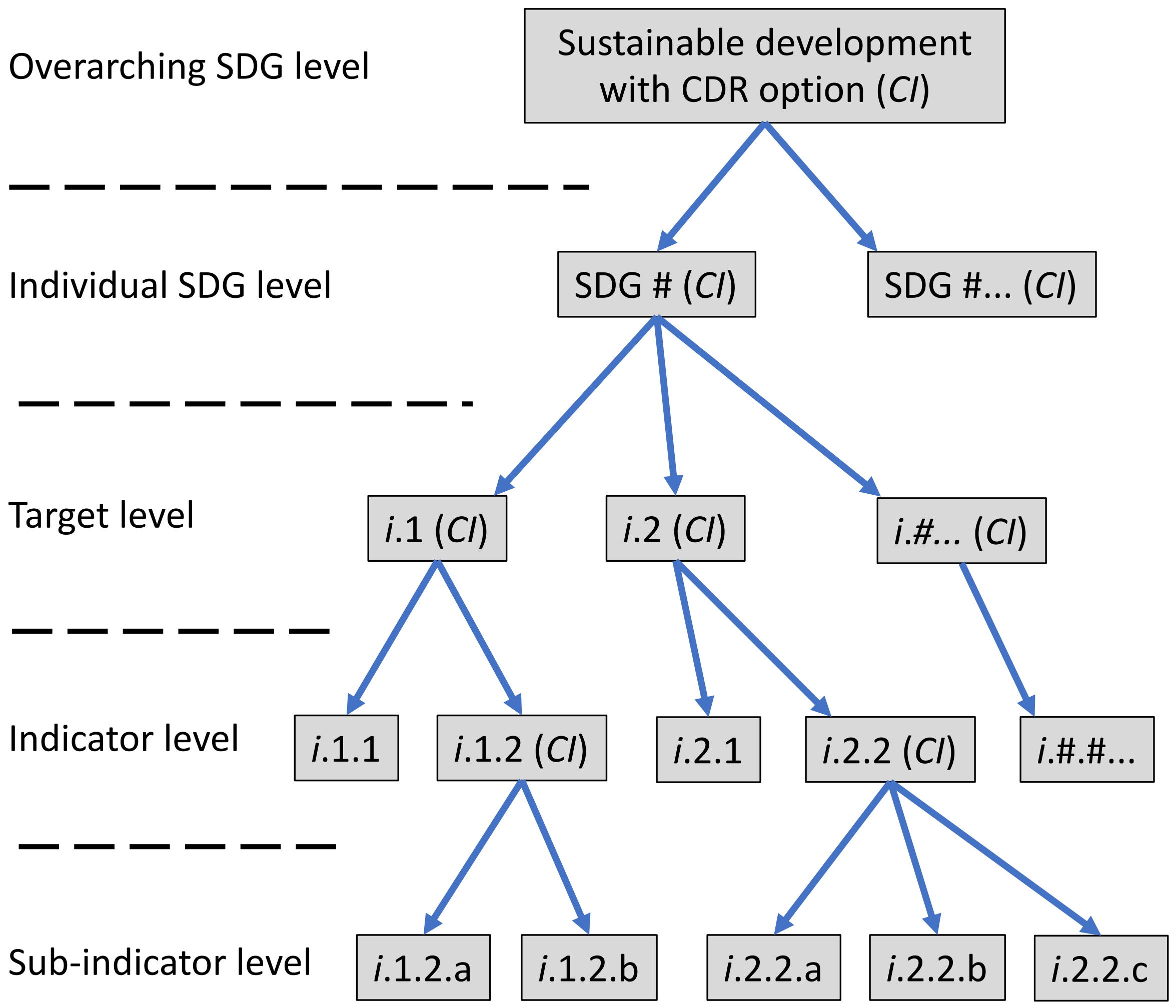

Figure 1. Assessment framework nesting structure that can be applied to quantify sustainable ocean-based CDR. i refers to individual SDG numbers and CI refers to the composite indicator (see equation 1) that is calculated using information from the level below.

As discussed in Rickels et al. (2016, 2019), the selection, normalization, weighting, and aggregation of indicators involves subjective and normative choices with important implications for the results. With a set of (non-monetary) indicators as proxies for capital stocks, it still remains an open question how sustainable development should be assessed when certain indicators increase while others decrease (by increase we mean when the indicator changes in a manner that helps achieve the target and SDG, and vice versa for an indicator decrease). Obviously, situations in which all indicators increase can easily be identified as sustainable development. Likewise, unsustainable development is easily identified as such when all indicators decrease. However, the typical situation is that while some indicators increase, others decrease. In such a situation, sustainable development assessment is not straightforward. With an indicator set of the kind found in the current outline for the SDGs, qualitative assessment and discussion are required for an assessment of the overall development. Such a qualitative assessment includes an implicit weighting of indicators. It also includes implicit assumptions on the substitution possibilities between the targets measured by the different indicators. These substitution possibilities determine how an increase in one indicator can compensate for a decrease in another. Consequently, the assessment based on indicator sets involves various normative judgments and decisions that are seldom made transparent or set out as such.

Using composite indicators comprising indicators for several targets demands an explicit treatment of these trade-offs, some kind of weighting scheme and an explicit specification of substitution possibilities. The explicit specification of potential substitution then paves the way for a clear distinction between weak and strong sustainability. In theory, the concept of weak sustainability allows for unlimited substitution and requires that the (weighted) aggregate of the various indicators does not decline. By contrast, the concept of strong sustainability does not allow for any substitution between the various targets at all. There are various methods to deal with the substitution possibilities, although the structure of the SDGs lends itself to an upwardly decreasing approach, with good substitution potential at the indicator and target levels (corresponding to a concept of weak sustainability) and poor substitution potential at the SDG level (corresponding to a concept of strong sustainability).

Aggregation into a composite indicator involves dealing with the different measurement units of the individual indicators that make them non-comparable. Comparability can be achieved by transforming the individual indicators, thus making for greater flexibility in aggregating them. Various methods for the transformation and normalization of individual indicators exist, e.g. OECD (2008). However, care must be taken during the transformation process to account for data properties and the objectives of the original measurement. In the context of the SDG indicator framework, information for the normalization scheme can be obtained from agreed target values for specific SDG targets and indicators.

2.3 Description of the assessment framework and the steps necessary to use it

Step 1: **Comprehensively compile information on the CDR approach(es) and its application**. A well-developed CDR future deployment scenario (e.g., a case study) or actual information on deployment should be used in this evaluation to provide enough information for the assessment framework to be utilized in a meaningful way. Ideally this will provide information at a local, national, or regional level, otherwise it becomes difficult to quantify progress (or not) towards meeting the sustainable development goals. As ocean-based CDR is still immature, it may be worth developing scenarios that consider CDR at a large-scale to explore how the CDR approach(es) could potentially help or hinder meeting the SDGs. Such scenarios are best developed with expert elicitation and stakeholder input. For further recommendations or ideas on scenario development see for example (Mengis et al., 2022; O'Neill, Kriegler, Ebi, et al., 2014; O'Neill, Kriegler, Riahi, et al., 2014; Pereira et al., 2018, 2019; Pereira, Kuiper, et al., 2021; Pereira, Morrow, et al., 2021). Note that if there is not enough information about how the CDR approach(es) may interact with different SDGs then only an incomplete assessment can be done, i.e., some SDG targets or goals will have to be excluded.

Step 2: **Map the CDR scenario or deployment activity and derive relevant data for the assessment of progress towards each SDG target via the use of indicators.** This can be done by looking at the CDR scenario or deployment information and noting if there would be any direct or indirect quantifiable impact upon each SDG target indicator, which in practice means going down the list of SDG indicators (https://unstats.un.org/sdgs/indicators/indicators-list/) and matching it with the corresponding CDR activity data, if such data exists. Note that in some cases the SDG target indicators have not yet been regularly quantified and thus, evaluation may be difficult. That is there are currently 77 Tier 2 indicators, defined as: indicator is conceptually clear, has an internationally established methodology and standards are available, but data are not regularly produced by countries. In cases where the relevant CDR data is the same as the SDG target indicator it can be used directly. For example, for ocean alkalinity enhancement (OAE) activities we would expect that data is available to evaluate SDG target *14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels* as the indicator is *14.3.1 Average marine acidity (pH) measured at agreed suite of representative sampling stations*, and pH is affected by OAE and should be quantified if OAE monitoring best practices are followed (Cyronak et al., 2023). If no direct indicators from the CDR activity are available and some relationship to the SDG indicator exists, then alternative indicators can be derived and utilized. For this we recommend following approaches as exemplified in Rickels et al., (2016, 2019). At the end of this step, you should have a table of indicators (or sub-indicators), along with their data, that correspond to each SDG target indicator.

Step 3: **Transform (normalize) indicator information for comparison.** Following Ebert and Welsch (2004), we suggest aiming for ratio-scale comparability for all indicators. To do this a ratio scale range can be set between 0 and 100 or 0 and 1, although we suggest the former to best incorporate results from some existing indicators that use such a range. For those indicators not yet available as ratio-scale fully comparable indicators, we suggest using either the distance-to-reference (dis-ref) transformation or max-min transformations (max-min) (OECD, 2008). Regarding the application of the max-min transformation one needs to keep in mind that high or low scores might not necessarily indicate a good or poor state. With the right data, see for example Rickels et al. (2019), one can interpret the maximum value as kind of a best-practice reference value. However, since for an increasing number of SDG indicators, target values are defined, the distance to reference transformation is preferred.

Step 4: **Aggregate the indicators for each SDG target to quantify sustainability for that particular target.** The fully comparable indicators developed in the prior step can be aggregated using a generalized mean to quantify progress towards each target. Note that in cases where there are sub-indicators for each main indicator a composite index will first need to be calculated for that indicator (Fig. 1). This approach follows Rickels et al., (2016, 2019) where a composite indicator (CI) is calculated:

Equation 1

$$CI(a_i, I_i, \sigma) = \left(\sum_{i=1}^{N} \alpha_i I_i^{\rho})\right)^{1/\rho}$$

with weights $\alpha_i > 0$ for the individual indicators, I_i, (or sub-indicators). The exponent ρ determines the substitution possibilities between the different indicators, determining how far the distribution of scores across the various indicators influences the overall score. To relate the application of the generalized mean to social choice theory and the parameter ρ is usually specified as:

Equation 2

$$\rho = \frac{\sigma - 1}{\sigma} \text{ with } 0 \leq \sigma \leq \infty$$

The parameter σ is used to quantify the elasticity of substitution between the different indicators. High (low) values for σ imply good (poor) substitution possibilities which means that the low score in one indicator can very well (not well) compensated by a good score in another indicator. Consequently, high and low values for σ correspond to concepts of weak sustainability and strong sustainability, respectively (Fig. 2).

To best determine the weights input from stakeholders and experts is recommended, although scientific guidelines exist for the specification of the substitution elasticity. See Rickels et al., (2016, 2019) for further discussion of this point and examples of how to make these calculations with limited information. For example, a Monte Carlo analysis (N = 10,000) can be conducted, assuming that σ is uniformly distributed between 0 and 1. This would provide information about the sensitivity of the results to the degree of sustainability strength.

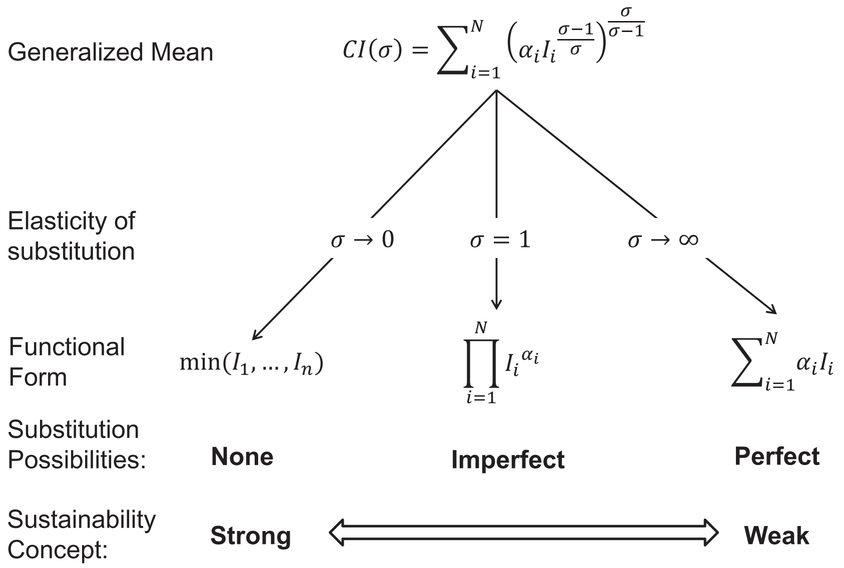

Figure 2. Special functional forms of the generalized mean in dependence of the elasticity of substitution and the corresponding substitution possibilities and sustainability concepts (from Rickels et al., 2016, 2019).

Step 5: **Aggregate the target level information to quantify sustainability for each SDG.** As in the prior step a CI can be calculated using the information from step 4 to quantify sustainability for individual SDGs. Unless the goal is to stop at the individual SDG level, then this step will need to be repeated for each SDG in preparation for the next step. Thus, at the end there should be 17 CIs, unless information is unavailable for some SDGs.

Step 6: **Aggregate the SDG level information to quantify sustainable development with the CDR option(s).** As in the prior step a CI can be calculated using the information from step 5 to quantify overall sustainable development. Depending on the weighting and substitution of elasticity that is used, it may be possible to classify sustainability in a range from weak to strong.

Step 7 (optional): **Compare SDG progress at local, regional, national levels, or over time.** If information is available at different spatial scales, e.g., at national levels, then steps 1-6 can be repeated for each and a comparison made. See for example, Rickels et al., (2016) who evaluated how EU coastal states scored towards SDG 14. Progress towards the SDGs over time can also be evaluated by including time in the CI equation (see equation 1 in Rickels et al., 2019). It should be noted though that the consistent application of normalization required for comparisons over time must have consistent reference levels applied and that scores from the past (e.g., from previous assessments) need to be recalculated when this is done.

2.4 Summary and Conclusion

Here we have developed a CDR SDG assessment framework that can be used to evaluate the sustainability of different ocean-based CDR options or portfolios. Once relevant data on the CDR approach has been collected, the approach transforms (normalizes) and aggregates SDG target indicators (and potentially also sub-indicators) to first quantify CDR impacts on progress towards each SDG target. This information is then further aggregated to quantify CDR impacts on progress towards each individual SDG goal. Finally, the information is aggregated again to quantify CDR impacts on progress towards overall “sustainability”.

The application of this framework is no trivial matter. Collecting data on CDR approaches or developing future scenarios of deployment requires much desk work, as well as potential expert elicitation and stakeholder input. Then care must be taken during the normalization, weighting, and aggregation of indicators. In some cases, this may again require expert elicitation and stakeholder input to ensure the optimal weighting and substitution of elasticity choices. Sensitivity analyses may also be useful, e.g., Monte Carlo analyses. In subsequent work, we hope to assess different ocean-based CDR options with this framework.

3. References

Cyronak, T., Albright, R., & Bach, L. T. (2023). Field experiments in ocean alkalinity enhancement research. *State of the Planet*, *2-oae2023*, 1–13. https://doi.org/10.5194/sp-2-oae2023-7-2023

Ebert, U., & Welsch, H. (2004). Meaningful environmental indices: a social choice approach. *Journal of Environmental Economics and Management*, *47*(2), 270–283. https://doi.org/10.1016/j.jeem.2003.09.001

Honegger, M., Michaelowa, A., & Roy, J. (2020). Potential implications of carbon dioxide removal for the sustainable development goals. *Climate Policy*, *0*(0), 1–21. https://doi.org/10.1080/14693062.2020.1843388

Horvath, S.-M., Muhr, M. M., Kirchner, M., Toth, W., Germann, V., Hundscheid, L., et al. (2022). Handling a complex agenda: A review and assessment of methods to analyse SDG entity interactions. *Environmental Science & Policy*, *131*, 160–176. https://doi.org/10.1016/j.envsci.2022.01.021

IPCC. (2018). *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*.

IPCC. (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (IPCC).

IPCC. (2022). *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*.

Mengis, N., Kalhori, A., Simon, S., Harpprecht, C., Baetcke, L., Prats-Salvado, E., et al. (2022). Net-Zero CO2 Germany—A Retrospect From the Year 2050. *Earth's Future*, *10*(2), e2021EF002324. https://doi.org/10.1029/2021EF002324

Moallemi, E. A., Hosseini, S. H., Eker, S., Gao, L., Bertone, E., Szetey, K., & Bryan, B. A. (2022). Eight Archetypes of Sustainable Development Goal (SDG) Synergies and Trade-Offs. *Earth's Future*, *10*(9), e2022EF002873. https://doi.org/10.1029/2022EF002873

Moreno, J., Van de Ven, D.-J., Sampedro, J., Gambhir, A., Woods, J., & Gonzalez-Eguino, M. (2023). Assessing synergies and trade-offs of diverging Paris-compliant mitigation strategies with long-term SDG objectives. *Global Environmental Change*, *78*, 102624. https://doi.org/10.1016/j.gloenvcha.2022.102624

Nerini, F. F., Sovacool, B., Hughes, N., Cozzi, L., Cosgrave, E., Howells, M., et al. (2019). Connecting climate action with other Sustainable Development Goals. *Nature Sustainability*, *2*(8), 674–680. https://doi.org/10.1038/s41893-019-0334-y

OECD. (2008). *Handbook on Constructing Composite Indicators: Methodology and User Guide*. Paris: Organisation for Economic Co-operation and Development. Retrieved from https://www.oecd-ilibrary.org/economics/handbook-on-constructing-composite-indicators-methodology-and-user-guide_9789264043466-en

O'Neill, B. C., Kriegler, E., Riahi, K., Ebi, K. L., Hallegatte, S., Carter, T. R., et al. (2014). A new scenario framework for climate change research: the concept of shared socioeconomic pathways. *Climatic Change*, *122*(3), 387–400. https://doi.org/10.1007/s10584-013-0905-2

O'Neill, B. C., Kriegler, E., Ebi, K. L., Kemp-Benedict, E., Riahi, K., Rothman, D. S., et al. (2014). The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. *Global Environmental Change*. https://doi.org/10.1016/j.gloenvcha.2015.01.004

Pereira, L., Hichert, T., Hamann, M., Preiser, R., & Biggs, R. (2018). Using futures methods to create transformative spaces: visions of a good Anthropocene in southern Africa. *Ecology and Society*, *23*(1). https://doi.org/10.5751/ES-09907-230119

Pereira, L., Sitas, N., Ravera, F., Jimenez-Aceituno, A., & Merrie, A. (2019). Building capacities for transformative change towards sustainability: Imagination in Intergovernmental Science-Policy Scenario Processes. *Elementa: Science of the Anthropocene*, *7*, 35. https://doi.org/10.1525/elementa.374

Pereira, L., Kuiper, J. J., Selomane, O., Aguiar, A. P. D., Asrar, G. R., Bennett, E. M., et al. (2021). Advancing a toolkit of diverse futures approaches for global environmental assessments. *Ecosystems and People*, *17*(1), 191–204. https://doi.org/10.1080/26395916.2021.1901783

Pereira, L., Morrow, D., Aquila, V., Beckage, B., Beckbesinger, S., Beukes, L., et al. (2021). From fAIrplay to climate wars: making climate change scenarios more dynamic, creative, and integrative. *Ecology and Society*, *26*(4). https://doi.org/10.5751/ES-12856-260430

Rickels, W., Quaas, M. F., & Visbeck, M. (2014). How healthy is the human-ocean system? *Environmental Research Letters*, *9*(4), 044013. https://doi.org/10.1088/1748-9326/9/4/044013

Rickels, W., Dovern, J., Hoffmann, J., Quaas, M. F., Schmidt, J. O., & Visbeck, M. (2016). Indicators for monitoring sustainable development goals: An application to oceanic development in the European Union. *Earth's Future*, *4*(5), 252–267. https://doi.org/10.1002/2016EF000353

Rickels, W., Weigand, C., Grasse, P., Schmidt, J., & Voss, R. (2019). Does the European Union achieve comprehensive blue growth? Progress of EU coastal states in the Baltic and North Sea, and the Atlantic Ocean against sustainable development goal 14. *Marine Policy*, *106*, 103515. https://doi.org/10.1016/j.marpol.2019.103515

Smith, P., Adams, J., Beerling, D. J., Beringer, T., Calvin, K. V., Fuss, S., et al. (2019a). Impacts of Land-Based Greenhouse Gas Removal Options on Ecosystem Services and the United Nations Sustainable Development Goals. *Annual Review of Environment and Resources*, *44*(1), annurev-environ-101718-033129. https://doi.org/10.1146/annurev-environ-101718-033129

Smith, P., Adams, J., Beerling, D. J., Beringer, T., Calvin, K. V., Fuss, S., et al. (2019b). Land-Management Options for Greenhouse Gas Removal and Their Impacts on Ecosystem Services and the Sustainable Development Goals. *Annual Review of Environment and Resources*, *44*(1), 255–286. https://doi.org/10.1146/annurev-environ-101718-033129