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1. Changes with respect to the description of work

Task 4.1 and its deliverable (D4.1) were originally scheduled to be finalized by February 2024. However, to allow for a better representation of the feasibility of climate neutrality commitments, an extension was granted until October 2024.

2. Dissemination and uptake

This deliverable is public and will be available at ELEVATE's website.

3. Short summary of results (<250 words)

Using a political economy lens, we provide the first comprehensive assessment of the feasibility of three international climate policy initiatives: internationally transferable mitigation outcomes (ITMOs), carbon removals (CRs) and loss and damage (L&D) initiatives. We assess enabling factors as well as barriers along seven categories, ecological, economic, geo-physical, geo-political, institutional, socio-cultural, and technological. In doing so, we use multiple indicators that focus on various aspects of each dimension. Our results give a nuanced and consistently comparable picture of how different initiatives compare. We find considerable differences regarding the evaluation of the political feasibility of different options. L&D initiatives, based on our methodology, seem to be associated with strong enabling factors in terms of feasibility, particularly as far as geo-political, technological and economic indicators are concerned. That said, even though CRs possess technological and economic enablers, their feasibility is more constrained due to the presence of ecological, geo-political, institutional and social-cultural barriers that hamper their realization. The feasibility of Internationally Transferred Mitigation Outcomes (ITMOs) can be enabled based on ecological, geo-physical, and socio-cultural grounds; yet, we find that particularly for ITMOs the feasibility is highly dependent on the specific country context and cannot not clearly be assessed in a fully generalizable pattern. Generally, country-specific constraints will have a decisive impact upon the feasibility of specific initiatives and their contribution to international mitigation efforts..

4. Evidence of accomplishment

See report below.

Version log

Version	Date	Released by	Nature of Change
1	23-10-2024	Nazlicicek Semercioglu	First draft
2	31-10-2024	Nazlicicek Semercioglu	Final version for submission, based on internal review

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1. Introduction

The Paris Agreement marked a departure from the Kyoto Protocol, which set mandatory emission reduction targets to a bottom-up approach where Parties submit voluntary, self -determined targets with the goal of increasing mitigation ambition over time. Under the Paris Agreement, in order to achieve the set goals, Parties can cooperate with one another by adopting market and non-market approaches. Notably, the global temperature increase can be limited to 1.5 ° C above pre-industrial levels as foreseen in the Paris Agreement if the steps taken to reduce emissions are coupled with carbon removal activities. Accordingly, there are a wide range of steps that states can take to reduce their emissions and remove carbon dioxide from the atmosphere. That said, there may be instances where climate change related losses and damages occur due to the failure of states to adopt adequate measures or the impossibility of preventing such adverse impacts notwithstanding the adequacy of the measures adopted by states.

The Paris Agreement highlights multiple instruments that allow states to cooperate to reach their climate mitigation goals, remove carbon dioxide from the atmosphere and address climate change related. Losses and damages that are novel and do not enjoy widespread implementation. Their political feasibility is widely unknown and has not been assessed in a comprehensive manner. Assessing the feasibility of climate policies and the political and economic context in which they operate is however crucial to their successful design, adoption, and implementation. Climate policies, by their nature, affect various sectors of society, influencing economic systems, political structures, and public welfare. Without a careful understanding of the political and economic context, even the most well-intended climate actions risk failure due to misaligned incentives, political resistance, or lack of financial viability.

In this deliverable we systematically assess the political feasibility of three different international initiatives regulated in the Paris Agreement, namely Internationally Transferred Mitigation Outcomes (ITMOs), Carbon Removals (CRs) and Loss and Damage (L&D) initiatives. We review existing concepts on how to assess political feasibility to define a set of indicators in multiple categories, including ecological, economic, geo-physical, geo-political, institutional, socio-cultural, and technological ones. As a result, we can provide a comprehensive assessment of the expected feasibility of various initiatives, including an assessment of possible political barriers for implementation.

This deliverable is organized as follows: Section 2 studies the changes that have been brought about by the introduction of the Paris Agreement to the governance of the actions taken towards reducing emissions. Section 3 examines the market and non-market approaches that can be adopted by states when engaging in cooperation to achieve their climate mitigation goals. Section 4 focuses on three aspects that are relevant for carbon removal activities, namely the conventional and novel carbon removal methods, proposed national framework for the imposition of carbon removal obligations as well as the potential creation of an international CDR market to allows states to pay for CR activities that take place abroad. Section 5 lays down the L&D initiatives. Section 6 assesses the feasibility of ITMOs, proposed national framework pertaining to CR obligations and international CR market as well as CR methods and L&D initiatives from a political economy perspective. Section 7 concludes.

2. The road to the Paris Agreement: from mandatory targets to voluntary commitments

In the 1980s, scientists recorded radical shifts in the climate of the Earth (Merrington, 2015). During this period, climate change became the subject of inter-state deliberations as a politically salient issue. This process culminated in the adoption of the UN Framework Convention on Climate Change ('UNFCCC') in 1992, the first binding instrument aiming to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (Kreienkamp, 2019; Maizland, 2023; UNFCCC, 1992). The UNFCCC does not set out detailed rules with respect to the emission reduction obligations of states due to being a framework convention (UNFCCC, 1992). The Kyoto Protocol that was adopted in 1997 enshrines concrete provisions in relation to such obligations mandating states "to reduce their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012". However, these obligations only applied to Annex I states that are industrialized (Kyoto Protocol, 1997; Parties to the United Nations Framework Convention on Climate Change; Parties & Observers). Accordingly, developing countries not included in Annex I have not been subjected to reduction obligations under the Kyoto Protocol (Falkner, 2016).

Even though Annex I countries were able to meet the reduction targets set by the Kyoto Protocol, their achievement failed to hinder the growth of emissions at the global level owing to some of the shortcomings of the Kyoto Protocol. In this respect, in setting a stable emission reduction objective for the period running from 2008 until 2012, the Kyoto Protocol lacked mechanisms that could be utilized to set divergent targets for states whose economies were industrialized to varying degrees. In addition, the mandatory nature of the emission reduction targets led some of the states where high emitting economic activities are concentrated to withdraw from the Kyoto Protocol or refrain from renewing their reduction pledges after 2012. Lastly, the Kyoto Protocol failed to account for the increasing economic growth generated in countries that started experiencing industrialization after its entry into force due to excluding them from Annex I (Falkner, 2016).

As the global community did not succeed in slowing down the rate at which global greenhouse gas emissions increased, a number of states reached a consensus concerning the necessity to adopt approaches that differ from those that have shaped the Kyoto Protocol. As a result, in the Copenhagen Accord that was drafted in 2009, states opted out from setting mandatory emission reduction targets and laid the groundwork for a system that operates on the basis of voluntary commitments made by governments. In addition, developing countries that have not been included in Annex I but later contributed to the growth of global emissions when their economies experienced industrialization agreed to take steps towards reducing their emissions alongside developed states (Falkner, 2016).

Against this background, the Paris Agreement was adopted in 2016 to achieve the same objective as the UNFCCC that sought to counter climate change by reducing greenhouse gas emissions (UNFCCC, 1992; Paris Agreement, 2016). That said, the Paris Agreement sets more ambitious goals compared to the previous benchmarks. In this regard, departing from the 2°C goal that had enjoyed acceptance, it aims to "hold the increase in the global average temperature to well below 2°C above pre-industrial levels" and "pursues efforts to limit the temperature increase to 1.5°C above pre-industrial level" (Paris Agreement, 2016; Falkner, 2016). Similarly, while the Kyoto Protocol did not prescribe a long-term objective, under the Paris Agreement, the parties should endeavour to "undertake rapid greenhouse gas emission reductions (…) so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gasses in the second half of this century." The latter goal, which has been referred to as "emissions balance", is geared towards the complete elimination of greenhouse gas emissions during the timeframe running between 2050 and 2100 (Paris Agreement, 2016; Falkner, 2016).

To achieve the goals of the Paris Agreement, parties are required to "prepare, communicate and maintain nationally determined contributions" every time a 5-year period elapses. Even though the latter obligation is legally binding, the agreement grants states a wide discretion with respect to the actions that they can take in pursuance of the objectives of the Paris Agreement by referring to them as "Nationally Determined Contributions" (NDCs). In this respect, it only highlights the expectation that states gradually increase the level of ambition of the actions they intend to take as part of such contributions (Paris Agreement, 2016).

3. Voluntary inter-state cooperation: market and non-market approaches

The Paris Agreement lays down a framework concerning the cooperation that can take place between states on a voluntary basis for the facilitation of the achievement of the objectives communicated in nationally determined contributions. In doing so, it categorizes the actions that states can take into three groups (Paris Agreement, 2016).

Within this context, countries can "use internationally transferred mitigation outcomes (ITMOs) towards nationally determined contributions" (Paris Agreement, 2016). These outcomes can cover both emission reductions and removals (Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement, 2021). Accordingly, a host country that can plausibly go beyond or has already exceeded the target that it has set for itself in its NDC may sell this outcome to a buyer country in return of financial support for activities that may contribute to climate mitigation but can only be carried out if sufficient funds are received. Once this transaction takes place, the host country cannot utilize the latter ITMO to make progress towards achieving its own NDC goal. Instead, the buyer country can count it as an action taken for the obtainment of the latter goal, thereby making progress towards decarbonizing its economy. ITMOs can be regarded as market mechanisms due to involving an exchange that generates benefits for both of the parties (Granziera et al., 2024).

The successful completion of ITMO transactions depends on the presence of a two-tier structure. First, states enter into bilateral agreements[1] laying down a framework for their cooperation for the sale and purchase of ITMOs. These inter-state agreements enshrine baseline standards to ensure that ITMOs do not generate adverse environmental impacts, incite social polarization, hinder the enjoyment of human rights and pose obstacles against the achievement of sustainable development objectives. In addition, they set out procedures governing the authorization of ITMOs in the host and buyer states as well as their "monitoring, verification and examination". Similarly, they lay down rules in relation to, among others, the manner in which both of the states should recognize the ITMO transfers, register them and ensure that they are deemed as progress made towards the achievement of NDC only in the buyer country[2]. Once the bilateral agreements

[1] See for instance the Cooperation Agreement between the Swiss Confederation and the Republic of Ghana towards the Implementation of the Paris Agreement (available online at: https://undp.org/press-releases/switzerland-and-ghana-sign-historic-agreement-climate-action, accessed on 24 October 2024); Low Carbon Development Partnership between the Japanese and Mongolian sides (available online at: https://env.go.jp/press/files/jp/21354.pdf, accessed on 24 October 2024); Framework Agreement for Cooperation on Climate between the Government of the Republic of Uzbekistan and the Government of the Republic of Korea (available online at: https://lex.uz/ru/docs/6658260, accessed on 24 October 2024). For a list of all the countries that have signed such agreements as of 7 October 2024, see UNEP (2024).

[2] See for instance Cooperation Agreement between the Swiss Confederation and the Republic of Ghana towards the Implementation of the Paris Agreement (available online at: https://undp.org/press-releases/switzerland-and-ghana-sign-historic-agreement-climate-action, accessed on 24 October 2024); Implementing Agreement to the Paris Agreement between the Swiss Confederation and the Republic of Peru (available online at: https://ercst.org/document/implementing-agreement-to-the-paris-agreement-between-the-swiss-confederation-and-the-republic-of-peru/, accessed on 24 October 2024); Framework Agreement for Cooperation on Climate between the Government of the Republic of

between states are adopted, private and public entities operating in them can make commercial deals for the sale and purchase of ITMOs in relation to certain projects (Kerschner and York, 2023). Notably, under this scheme, the freedom of states to set the terms of ITMOs is not restricted by the rules set by an international body, rendering it “decentralized” and “bottom-up” (Asian Development Bank, 2019).

Following the entry into force of the Paris Agreement in 2016, an increasing number of countries have started considering the establishment of bilateral frameworks for the exchange of ITMOs as a viable path for entering into cooperation with the aim of making progress towards achieving their nationally determined contributions (Granziera et al., 2024). That said, only 20 agreements have been signed so far and the majority of the agreements are under negotiation or still being drafted (UNEP, 2024). In addition, only one ITMO transaction has been made up until now. This agreement has provided financial resources for the substitution of buses in Bangkok that operate by internally burning fuel with vehicles that function with electrical power. Other projects for which transactions will be completed pertain to certain outcomes that host countries seek to achieve such as the uptake of environmentally sustainable agriculture practices, use of solar energy, waste circulation and use of sustainable cooking fuels (Granziera et al., 2024; KLIK, 2024).

Besides ITMOs, the Paris Agreement lays down another process that can be triggered for the purpose of engaging in voluntary cooperation and is governed by the Paris Agreement Crediting Mechanism (Paris Agreement, 2016; Paris Agreement Crediting Mechanism). Unlike the process leading up to the transfer of ITMOs that is governed by states, availing of this option entails the evaluation of mitigation targets achieved by states by independent international bodies operating at the central level (Asian Development Bank, 2019). The adoption of a market-based approach under this scheme leads to the emergence of a process that is the equivalent of ITMOs (Paris Agreement Crediting Mechanism). Accordingly, under this scheme, project developers that contribute to the mitigation of greenhouse gasses by reducing their emission or removing them can have this impact approved by the state where they operate. Then, they can have recourse to the Supervisory Body established under the Paris Agreement that issues carbon credits (Kerschner et al., 2023). As the rules concerning the modalities that the Paris Agreement Crediting Mechanism will adopt in exercising its functions are still being formulated, state parties cannot currently trade carbon credits by making requests to this body (Kerschner et al., 2024; UNFCCC Subsidiary Body for Scientific and Technological Advice, 2024; Rules and Regulations). Frameworks pertaining to the activities of the Paris Agreement Crediting Mechanism can be finalized at the soonest during the COP29 that will take place in November 2024 (Granziera et al., 2024).

Uzbekistan and the Government of the Republic of Korea (available online at https://lex.uz/ru/docs/6658260, accessed on 24 October 2024).

Lastly, the Paris Agreement has set the framework for a non-market based mechanism whereby parties can provide assistance to one another to facilitate the completion of actions foreseen in their respective NDCs without trading carbon credits or gaining benefits in another way (Paris Agreement, 2016; Granziera et al., 2024). Unlike the provisions laying down the main features of market-based mechanisms, the rules governing non-market based approaches under the Paris Agreement merely provide a framework and do not spell out the measures that fall within the scope of such approaches (Paris Agreement, 2016). Within this context, "the non-market mechanism can be anything and everything, provided it's not market-based" (United Nations Climate Change, 2024). In fact, in establishing a work program in relation to non-market approaches, the Conference of Parties has laid down three focus areas, namely "adaptation, resilience and sustainability, mitigation measures to address climate change and contribute to sustainable development, development of clean energy sources" in a non-exhaustive manner. In a similar vein, it has only provided examples in relation to the areas the participating countries can benefit from assistance such as "mitigation, adaptation and contribution to sustainable development" (Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement b, 2021). Up until now, no measure has been taken that is explicitly geared towards engaging in voluntary cooperation through the adoption of a non-market based approach within the framework set by the Paris Agreement (Villarino et al., 2024). Pilot projects that have recently been developed for this purpose are yet to be recognized as non-market mechanisms within the meaning of the Paris Agreement (Anderson, 2022).

4. Carbon removals

The Paris Agreement seeks to limit the global temperature increase to 1.5 °C above pre-industrial levels (Paris Agreement, 2016). This goal can only be achieved if the target of net zero emissions can be reached at the global level by 2050 when all carbon emissions are removed from the atmosphere through the utilization of carbon removal methods (Levin et al., 2023). In addition, there is consensus that a temporary overshoot of the temperature target is unavoidable under the most stringent interpretation of the Paris Agreement. This means that after reaching net-zero emissions a part of the emitted carbon stock would need to be removed from the atmosphere via CR. Furthermore, it has been proposed that regions highly responsible for past climate change should remove a part of the carbon emitted historically (Bednar, 2019). In fact, activities falling within the scope of mitigation outcomes that can be transferred under the Paris Agreement as part of voluntary inter-state cooperation can not only involve emission reduction but also carbon removal (Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement a, 2021; Kerschner et al., 2023).

Within this context, around 1500 entities that include governments, federal states, regions, cities and publicly-listed companies have set net zero targets. Governments that have set such targets release 88% of global greenhouse gas emissions. In addition, they produce 92% of global GDP and host 89% of the global population. Similarly, federal states and regions that have net zero targets host 1457 million people and 787 million people live in cities with a population exceeding 500.000 that have the same targets. This trend has also enjoyed considerable diffusion among publicly-listed companies. Around half of the Forbes 2000 companies with a revenue of US$ 26.4 trillion have net zero targets (Net Zero Tracker, 2023).

Against this background, this section first lays down the methods that can be used for carbon removal. Second, it sets out the domestic framework stipulating carbon removal obligations (CROs) that has been proposed by Bednar et al. (2023). Lastly, it studies the creation of an international CDR market as suggested by Lee et al. (2021).]

Carbon removal methods

CDR operations can be carried out by having recourse to a number of methods with varying characteristics. While some of such methods are considered to be conventional due to enjoying widespread utilization, others are novel and are currently deployed as part of small projects. 99.9% of all CDR activities rely upon conventional methods. That said, the use of novel methods is growing faster compared to conventional methods (Geden et al., 2024).

Afforestation and reforestation are the methods that provide the largest contribution to conventional CDR (Geden et al., 2024) and are implemented by planting trees to form a forest. While the former method is employed in areas that previously lacked a forest, the latter method is utilized in places that initially comprised a forest (Australian Government Clean Energy Regulator, 2024). Their use results in the reduction of carbon through greater carbon sequestration (Turner et al., 2023). Another method that is considered to be conventional is agroforestry (Geden et al., 2024) that can be implemented by planting trees in agricultural lands (Hart et al., 2023). Similarly, some methods that are considered to be conventional (Geden et al., 2024) improve forest management by only harvesting old trees to allow them to get larger and remove greater amounts of carbon from the atmosphere (Butsic, 2023). The utilization of these methods allow forests to store great quantities of carbon by sinking it on a continuous basis (Fargione et al., 2018). Relatedly, the use of wood products that have a long life span is considered to be a conventional carbon removal method that is significant for storing carbon for an extended period of time (Geden et al., 2024; Gustavsson et al., 2006).

Soil carbon sequestration and wetland restoration are the other conventional methods that are used to remove carbon (Geden et al., 2024). Under the first method, the carbon maintained as organic matter in the soil of fields that are used to grow crops and graze animals is increased (Paustian et al., 2019). To achieve this end, various land management strategies are used. These include the utilization of practices that require little to no land tilling in order to prevent soil disturbance to the extent possible, changing the frequency at which crops are planted and their type, limiting the extent to which lands are used for grazing and applying plant residues to fields (American University f, 2020; Ren et al., 2024). This approach is advantageous as it increases the carbon storage capacity of agricultural fields without changing their purpose of use by converting them to forests and therefore does not result in greater competition to use them (Paustian et al., 2019). Under the second method, degraded wetlands are restored to enable them to exercise their regular functions that include the storage of great quantities of carbon. Importantly, wetlands store more carbon than forests (Wetland Restoration for Climate Change Resilience, 2024; US Environmental Protection Agency, 2024).

Even though the conventional CDR methods remove over 50% of the carbon emissions (Chandrasekhar et al., 2023) the amount of carbon emissions that have been released has recently been almost the same as that removed by these natural processes. This situation has decreased the net amount of carbon that is absorbed by them (Velde, 2024).

Novel CDR methods include “bioenergy with carbon capture and storage, direct air carbon capture and storage, enhanced rock weathering, biochar, and ocean alkalinity enhancement” (Geden et al., 2024). Bioenergy with carbon capture and storage is employed through the capture and storage of carbon during processes where biomass is utilized for energy generation. It is the only CDR method that can also generate energy (IEA, 2024). Direct air capture utilizes a technology that pulls carbon from air and moves it over chemicals that sequester carbon. The captured carbon can either be stored underground or utilized in other products. While the use of carbon in products such as concrete and plastic can ensure its sequestration for extended periods of time, its utilization for manufacturing beverages or synthetic fuels can lead to rapid carbon emissions. Even though the utilization of the latter product has more environmental benefits compared to the use of fossil fuels, the climate mitigation benefits of direct air capture can only be maximized if vast amounts of carbon is captured underground permanently (Lebling et al., 2022). Enhanced rock weathering is a method utilized to accelerate the extremely long natural process where the weathering of silicate rocks permanently captures carbon from the atmosphere (Puro Earth, 2024). Accordingly, this method is employed by inserting silicate rock that is obtained by having recourse to widely used technologies to soil (Puro Earth, 2024 Levy et al., 2024). The employment of biochar carbon removal necessitates the production of biochar through applying high heat in an environment with restricted amount of oxygen with the aim of turning biomass into biochar, a type of carbon with long durability than can store atmospheric CO_2 for a long period of time. A large share of biochar is placed in soil. Its insertion into construction supplies like concrete can also enable carbon removal in the long term (Moya, 2023). Of all the novel CDR methods, biochar captures the largest share of carbon, followed by bioenergy with carbon capture and storage and enhanced rock weathering (Geden et al., 2024).

The pledges that have been made by governments to employ CDR methods are not sufficiently ambitious for limiting the temperature increase to 1.5 °C (Lamb et al., 2024). This situation stems from a number of reasons. First, the existing technological and commercial conditions are not suitable for the large scale uptake of CDR activities. Second, the funds that have been spared for the employment of CDR methods are not sufficient. Third, CDR is not adequately regulated due to the lack of appropriate monitoring, reporting and verification schemes. Fourth, public awareness with respect to CDR tends to be low owing to concerns related to greenwashing, safety, technical ambiguities resulting from lack of sufficient research and the potential of CDR to deter climate mitigation actions (Luck et al., 2024).

Carbon removal obligations

Reaching to the threshold of net-negative emissions (both at the global and regional scale) following the achievement of net zero emissions are expected to be very costly. Prior to the achievement of net-zero emissions, CDR costs can be paid for by the revenues of carbon markets such as the European Emission Trading Scheme (ETS). After net-zero, however, carbon revenues would dry up and CDR costs would be paid for by future generations unless an intertemporal instrument is put in place to finance future removals (Bednar, 2019). To address this shortcoming and avoid future policy failure, a framework based upon carbon removal obligations (CROs) with two elements, the CRO mechanism and CRO pricing instrument, has been proposed (Bednar et al., 2023). So far, this instrument has only been proposed in academia. However, with discussion around net-negative emission targets for the European Union intensifying, this mechanism could provide a valuable policy instruments to avoid overburdening future public budgets with the costs of removal, which would decrease the feasibility of large scale net-negative emissions.

Under the CRO mechanism, commercial banks that act as issuing entities issue a removal obligation to emitters for each tonne of released CO_2 that is higher than the remaining cumulative carbon budget for the region/country, or - if CROs are implemented on top of a carbon trading scheme like the ETS, higher than the yearly cap of the cap-and-trade market. CROs require emitters to remove the amount of carbon exceeding the carbon budget upon their maturity (Bednar et al., 2023). This obligation can be discharged through the utilization of removal units (Macinante and Ghaleigh, 2022) that can be purchased on a CDR market or obtained through the certification of CDR operations carried out by the emitter. The establishment of CDR markets are expected to ensure the competitive trade of removal units, thereby enabling entities that can engage in CDR to discharge their obligations by incurring minimum costs (Bednar et al., 2023).

The CRO pricing instrument is utilized for the determination and implementation of a suitable CRO premium that emitters pay between the issuance of CROs and maturity. The CRO base premium is set by central banks that are regulators. Commercial banks acting as issuing entities impose additional commercial premiums that need to be paid to them in addition to the base premium and ascertain maturity profiles. Since commercial banks can be held liable in cases where emitters fail to engage in CDR activities, the latter assessment is made to minimize the risks that are peculiar to emitters. In this regard, emitters with strong financial positions are more likely to be granted long maturities and low premiums. On the contrary, the weakness of the financial position of emitters can shorten the maturities and increase the premiums (Bednar et al., 2023). The premium amount can emerge as “carbon debt interest rate” (Bednar et al. 2021), a fee paid in several instalments or a one-time payment made by the emitter when the CRO is issued (Bednar et al., 2023).

This framework offers a number of advantages. First, it enables the integration of climate change mitigation activities that are carried out by having recourse to CDR into the economy through the utilization of existing principles that lead financial debts to generate interest. As a result, emitters are not only required by law to remove carbon, but also obliged to make payments as long as they continue releasing emissions. The application of this rule provides room for the implementation of the polluter pays principle (Bednar et al., 2023). Even though this scheme can be regarded and utilized as a “license to pollute” by operators that can release emissions as long as they can pay for it (European Environment Agency, 2020), it can receive considerable private investment as the foundation of a CDR market that can function adequately in the short term. Second, setting prices for CROs prevents emitters from opting to achieve net zero targets in the late 2000s and incentivizes them to reduce emissions and engage in CDR in the short term (Bednar et al., 2023). In doing so, it decreases the moral risks (Fankhauser and Hepburn, 2010) that would emerge in a scenario where no CRO premium is paid and the uptake of climate mitigation activities are disincentivized. As a result, this scheme ensures that CDR is implemented in addition to emission reductions and does not replace them (Bednar et al., 2023).

Implementing a CRO scheme faces the same practical challenges, and holds the same requirements, as for example integration of CDR into market schemes like the European ETS. Notably, this requires development of legislative frameworks, as well as regulatory bodies, to define and enforce monitoring, reporting and verification (MRV) standards for different CDR options (Burke et al., 2024). Furthermore, since future costs of technological CDR are at the moment highly uncertain (especially for certain technologies like DACCS), a potential implementation pathway of CROs should ensure instruments to avoid speculation or excessive optimism over future expected cost of removal by firms. This objective could be obtained by progressively introducing CROs with a base interest rate that is very high - to reflect risk aversion about future cost uncertainty of CDR - and relaxing the interest rate over time when information about cost of removal is updated.

International CDR market

Developed states where industrialization occurred at a rapid pace following the Industrial Revolution have released the largest amount of emissions for a long period. During this time interval, industrial activities were yet to take place in countries that are currently considered to be developing and therefore they released negligible amounts of emissions compared to those that originated from their developed counterparts (Vigna et al., 2024). Therefore, expecting all countries to achieve net-zero emissions at the same time would result in the imposition of disproportionate burdens upon developing countries and contravene the Paris Agreement that is guided by the principle of common but differentiated responsibilities and/or capabilities (Paris Agreement, 2016). Accordingly, developed countries that hold historical responsibility for the rise in emissions and possess the means for achieving net-zero might need to make progress towards achieving net-zero at an accelerated pace compared to countries that have contributed less to global emissions and/or set net negative emission targets earlier than other countries (Lee et al., 2021). Against this background, in order to enable countries to cover the costs of CDR activities that take place outside of their territories, Fajardy and Mac Dowell (2020) have suggested the creation of an international CDR market so as to enable the trading of negative emissions. As some regions may be removing less carbon that they should due to the elevated costs or a lack of resources, this scheme would enable countries to receive funds so as to remove carbon on behalf of other countries (Fajardy and Mac Dowell, 2020).

5. Loss and damage initiatives

Loss and damage is an umbrella concept that has been utilized during the deliberations that have been held under the auspices of the UN to counter climate change. There is no stand-alone definition that authoritatively sets out the adverse impacts of climate change that may be categorized as loss and damage (Bhandari et al., 2024). Pursuant to the Paris Agreement, “extreme weather events and slow onset events” are among the drivers of loss and damage (Paris Agreement, 2016), with the former phenomenon involving “droughts, heatwaves and storm surges” and the latter incidences occurring as a result of “rising sea levels, glacial retreat, desertification and loss of biodiversity” (Bhandari et al., 2024).

Climate change-related loss and damage can have an economic nature, adversely impacting essential infrastructure, property and supply chain operations. In addition, it can have non-economic consequences in cases where communities hit by the adverse impacts of climate change mourn the death of their families and suffer from agony when they cannot engage in cultural practices and are forced to leave the countries that have hosted them since ancient times (Bhandari et al., 2024). Likewise, non-economic consequences can emerge due to the adverse effects suffered by the environment as a result of loss and damage (Green Climate Fund, 2020).

Under the Paris Agreement, in countering climate change, states should “avert, minimize and address loss and damage” (Paris Agreement, 2016). In this respect, certain losses and damages can be “averted and minimized” through the mitigation of their adverse effects by reducing the greenhouse gas emissions and reinforcing the adaptive capacity of communities to tackle climate change by taking precautionary measures (LSE Grantham Research Institute on Climate Change and the Environment, 2022; Bhandari et al., 2024). Some of such losses and damages have indeed been avoided by taking measures geared towards “mitigation and/or adaptation”. On the other hand, others have occurred despite having an “avoidable” nature due to various barriers that are either financial, technical or political or have emerged due to circumstances that are peculiar to a given case. The third category of losses and damages are made up by those that cannot be avoided by taking “mitigation and/or adaptation measures” and include those that have arisen as a result of “coral bleaching, sea level rise and extreme events where no adaptation efforts would have helped prevent physical damage” (Verheyen and Roderick, 2008; Mechler R., et al., 2019). As a result, the latter group of losses and damages cannot be “averted and minimized” but be “addressed” through the provision of various types of support (Bhandari et al., 2024).

In this regard, traditionally, developing states whose actions have driven climate change to a negligible extent have been hit hardest by climate change induced loss and damage due to the policies adopted by developed countries that are deemed to be the actors with major responsibility for climate change (LSE Grantham Research Institute on Climate Change and the Environment, 2022; Bhandari et al., 2024). For over 30 years, developing countries in general, and island states in particular, have portrayed the matter as a compensation request and sought to have developed countries from the global north be held liable to rectify their situation. However, developed countries have strived to ensure that provision of support is not categorized as admission of liability. As a result, the terms “liability” and “compensation” have not been provided in the provisions of the Paris Agreement regulating loss and damage (Bhandari et al., 2024; Paris Agreement, 2016). In addition, during COP22 and COP23, conferences during which parties to the UNFCCC convened to hold deliberations, it has been highlighted that “funding arrangements, including a fund, for responding to loss and damage are based on cooperation and facilitation and do not involve liability or compensation” (Decision 1/CP.28, 2023).

The issuance of the Bali Action Plan in 2007 by the Conference of the Parties of the UNFCCC marked the first instance where the significance of addressing loss and damage was highlighted during inter-state deliberations held under the auspices of the UN (Bali Action Plan, 2007; Bhandari et al., 2024). However, this matter started receiving more attention in 2013 during the Conference of the Parties of the UNFCCC that culminated in the establishment of the Warsaw International Mechanism on Loss and Damage with the purpose of providing support to countries tackling loss and damage (Warsaw International Mechanism for Loss and Damage Associated with Climate Change Impacts, 2024; Bhandari et al., 2024). During the years following its establishment, the Warsaw International Mechanism on Loss and Damage failed to make concrete progress to reach its goals (Palumbo, 2020; Douglas et al., 2021).

That said, auspicious developments have taken place following the failure of the Warsaw International Mechanism on Loss and Damage. In this respect, the emergence of loss and damage as a common theme that enabled developing countries to form a united front led to the establishment of the Glasgow Dialogue in 2021 by the Conference of the Parties of the UNFCCC to enable states and non-state parties to deliberate about the manner in which actions taken to counter loss and damage can be funded (Skeaping, 2023; Decision 1/CMA.3, 2021). In addition, the Santiago Network was established by the Conference of the Parties of the UNFCCC in 2019 as part of the Warsaw International Mechanism on Loss and Damage “to catalyse the technical assistance of relevant organizations, bodies, networks and experts for the implementation of relevant approaches at the local, national and regional level in developing countries that are particularly vulnerable to the adverse effects of climate change” (Decision 2/CMA.2, 2019). The EU, several EU member states and the UK have made pledges that have reached the sum of US$ 40 million to financially contribute to the activities of the Santiago Network (United Nations Office for Disaster Risk Reduction, 2023).

Notably, during COP27, in a decision ushering in a new era, state parties to the UNFCCC agreed for the first time to make formal arrangements with respect to the provision of funding to assist states countering loss and damage (Decision 2/CP.27, 2022; UNFCCC, 2022). As a result, a number of countries undertook to make payments totalling US$700 million. In addition, the World Bank was selected as the institution to host the fund. There are still ambiguities with respect to the extent to which the World Bank can discharge its duties in an independent manner, ensure that all parties to the Paris Agreement can access the fund, swiftly meet the needs of countries seeking assistance and transfer funds that are of sufficient quantity for countering loss and damage (Bhandari et al., 2024).

There are also other initiatives operating without the involvement of the UN that have financed activities that have been carried out to address loss and damage (Bhandari et al., 2024). In this respect, the Global Shield against Climate Risks, which was launched during COP27 by the Vulnerable Twenty Group and the Group of Seven (G7) that are respectively composed of states that have been hit hardest by climate change and the seven biggest economies worldwide, seeks to safeguard people and states from the adverse effects of climate change by enhancing their capacities to tackle with loss and damage (V20, 2024; Government of Canada, 2024; Federal Ministry for Economic Cooperation and Development ,2024). This initiative has received support from a number of developed countries and Germany has made an investment of € 1 billion to create funds for climate risk and insurance (Federal Ministry for Economic Cooperation and Development, 2024). Similarly, the Global Facility for Disaster Reduction and Recovery, an initiative that receives funding from a variety of donors, in supporting the efforts made by countries that are not economically advanced (GFDRR and the World Bank, 2022) to comprehend, tackle and lower the risks they face due to natural disasters and climate change, finances the measures taken by such countries to counter loss and damage. Lastly, a number of civil society organizations have pledged to financially support loss and damage initiatives (Bhandari et al., 2022).

Despite the multiplicity of the channels that have been utilized to provide funding to address loss and damage, current financial flows are far from sufficient for meeting the needs of countries and communities. In this respect, it is impossible to precisely quantify the expenditures borne by countries that suffer from loss and damage as it is a process involving a number of ambiguities related to calculations, the policy choices made by all of the countries involved (Wenger and Johnson, 2023) as well as the establishment of causality between certain losses and damages and emission of greenhouse gases (Garcia, 2020). That said, rough estimates suggest that costs that have varied between US$ 116 billion and 435 billion in 2020 worldwide will range from US$ 290 billion and US$ 580 billion in 2030. Currently, funds that have been raised as part of UN initiatives are way below the latter estimates (Markandya and Eguino, 2018). For instance, the pledges that have been made for the payment of approximately US$ 700 million during the COP28 can only cover around 0.2% of the climate change-related losses endured by developing countries annually (Seega, 2023). The gap between current financial flows and the threshold the transfers need to reach to enable countries to better counter loss and damage has not occurred due to the insufficiency of resources possessed by developed countries. Instead, the latter disparity stems from the reluctance of such economically advanced countries to allocate the resources that are spent on providing financial incentives to corporations that produce and utilize fossil fuel to launch loss and damage initiatives (Richards and Jowahir, 2023).

6. Assessing the feasibility of ITMOs, L&D initiatives and CRs from a political economy perspective

Transactional costs, political feasibility and institutional capacity are significant factors that impact the implementation of ITMOs, CRs and L&D initiatives (Richards et al., 2023; Marz et al., 2021; Förster et al., 2022). They are also fields of inquiry that are frequently explored by those studying political economy, which examines the manner in which political and economic systems influence one another (Serrat, 2011; Whaites et al., 2023; Caballero and Soto-Oate, 2016). In this respect, the feasibility of climate action has been frequently scrutinized from a political economy perspective (Lamb and Minx., 2020; Hallegatte et al., 2024; Galanis et al., 2022).

Against this background, even though it is difficult to adopt a standard approach to define and assess feasibility that can be used across climate policies, several attempts have been made. The economic, technological, socio-cultural, institutional, geophysical and ecological dimensions have been introduced by the IPCC (IPCC, 2022) and used by Steg et al. (2022) and Jewell and Cherp (2023). In addition, given the significance of geopolitics for climate action (Climate Diplomacy, 2023; Borrell, 2023) and the fact that the initiatives under evaluation are intertwined with global power dynamics and national economic interests, the researchers of the ELEVATE project have assessed the latter instruments from a geopolitical perspective. Notably, taking this multidimensional approach helps policymakers understand not only the technical viability of climate solutions but also the broader social, political, and economic challenges that could either support or hinder their implementation (Steg et al. 2022).

Citing recent studies (de Coninck, H. et al., 2018; Khourdajie, A. et al., 2022; Steg, L. et al., 2022), Jewell and Cherp (2023) have identified indicators that can be used to make feasibility assessment with respect to the first six dimensions. The use of these indicators has enabled the researchers of the ELEVATE project to comprehensively evaluate how the introduction of each initiative impacts various aspects of a given dimension. Importantly, reliance on different indicators has prevented the emergence of generalizations with respect to each dimension and facilitated the demonstration of the complexities of a political economy assessment. To this end, the researchers have observed how each indicator within a dimension can be associated with different impacts.

For instance, when evaluating the impact of the introduction of ITMOs upon indicators that belong to the ecological dimension, as shown in Figure 1, the researchers have concluded that the introduction of ITMOs can affect the generation of toxic waste, water quality, biodiversity and water use both positively and negatively. That said, they have ascertained that the introduction of ITMOs would respectively have negative and positive effects upon air pollution and emission reduction. As shown in Figure 1, a similar trend has emerged with respect to the impacts the introduction of ITMOs would have on the indicators that belong to the economic dimension, namely growth, productivity, cost effectiveness and employment, as well as those that have been categorized under the geophysical dimension, the latter being land use limitation, physical potential and limited use of scarce geophysical resources. The extent to which the indicators belonging to the same dimension can be associated with varying impacts has also been illustrated in Figure 2 that demonstrates the outcome of the feasibility assessment that has been carried out in relation to CRs. Accordingly, with respect to the geopolitical dimension, while bargaining power in bilateral contracts and control over implementation institutions have been associated with negative impacts, costs and benefits for recipient/donor countries have been given a ranking that denotes that the introduction of CRs can have both positive and negative impacts. A similar picture has emerged in relation to the socio-cultural dimension and technological dimensions that have indicators for which various rankings have been given. The socio-cultural dimension includes five indicators, inter-generational equity, co-benefits, public acceptance, distributional effects and inclusiveness. The technological dimension has been assessed on the basis of four indicators, maturity, scalability, simplicity and risk. Lastly, as shown in Figure 3 that presents the outcome of the feasibility assessment that has been carried out with respect to L&D initiatives, the institutional indicators, namely cross-sector coordination, transparency/accountability, legal/administrative feasibility, institutional capacity and political acceptability, have been associated with varying impacts.

To detect the situations where the introduction of the relevant instrument impacts a given indicator positively, negatively or has no impact upon it, the signs “+”, “-“ and “0” have been used. In doing so, the extent to which the indicators would be an enabler (positive impact) or barrier (negative impact) to the implementation of a selected initiative has been identified. For example if a given international policy is deemed to have a positive impact on an ecological indicator, this is considered as an enabler and vice-versa. In cases where it has been concluded that the introduction of a given instrument would have no impact upon an indicator, the sign “0” has been used. In some cases that mostly involve the impact of an instrument on different set of countries (i.e. transferrer and recipients of ITMOs and countries that transfer and receive funds as part of L&D initiatives) and the use of diverse CDR methods, it has been concluded that the introduction of the relevant instrument can have both positive and negative impacts. Therefore, the signs “+/-“ have been used to denote this varied impact, meaning that the indicator can both be an enabler (positive impact) or barrier (negative impact) depending on the country or CDR method at stake.

The researchers have conducted literature review to be able to reach a conclusion with respect to the manner in which the introduction of the instruments affect the indicators. Each research institute was tasked with the evaluation of certain dimensions. Accordingly, the economic, socio-cultural, institutional and geo-political dimensions have been assessed by MCC[3]. The technological and ecological dimensions have been examined by CMCC[4]. Lastly, the geo-physical dimension was ranked by PBL[5]. Following the provision of initial results, discussions have been held by the institutes to take into account the views expressed by all of the researchers prior to the finalization of the tables.

[3] MCC Mercator Research Institute on Global Commons and Climate Change.
[4] CMCC Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici.
[5] PBL Netherlands Environmental Assessment Agency.

ITMOs

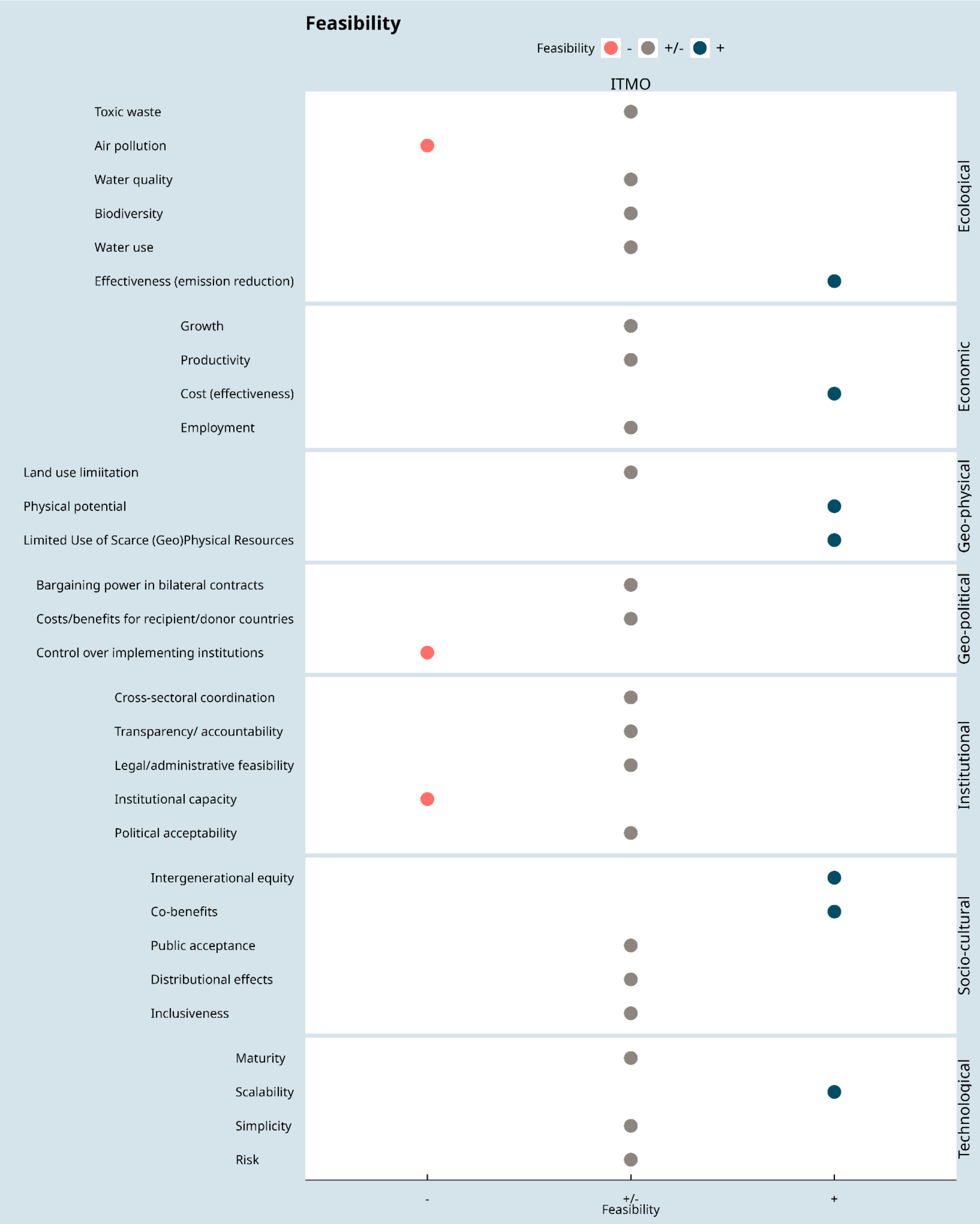

Figure 1 – Impacts of the introduction of ITMOs

ITMOs provide countries with an alternative way to reach countries targets through participation in the global carbon market, as such they tend to be effective and efficient to reduce emissions and they lower the marginal cost of abatement (Jiang, H. et al., 2023). Additionally, reformulations to improve clarity and foster collaborations were made since the introduction of the Kyoto cap and trade proposed mechanism (Kotagodahetti et al., 2022). Likewise, there is reason to believe that ITMOs are likely to yield co-benefits for air pollution as they promote emissions reductions, particularly in areas where exposure is high. Specifically, emission reductions in densely populated regions such as South and Southeast Asia are likely to produce significant co-benefits due to the reduced exposure of a large number of people (Cabezas et al., 2023; Akimoto et al., 2018). Please note that the sign is negative as it is likely that ITMOs will decrease air pollution but they are factored in as a feasibility enabler. With respect to the toxic waste indicator the relationship is less clear. On the one hand, it is positive to get rid of fossil fuel and refineries' toxicity, but on the other hand, carbon capture and storage technology and material mining for energy storage may increase the use and production of toxic materials (Mas-Fons et al., 2024).

As far as water use, biodiversity and water quality are concerned, countries that receive ITMOs are considered to have made progress towards reaching their NDCs (Paris Agreement, 2016) therefore ITMOs do not directly impact these indicators in such countries. Countries that transfer ITMOs receive funding to implement projects that seek to contribute to sustainable development (UNDP, 2023). Given that the latter projects can have a wide range of environmental, social and economic benefits, whether or not their implementation affects these indicators and the type of effect (positive or negative) depends on the type of project (UNEP, 2024).

In relation to economic indicators, while ITMOs are potentially cost-effective, they have mixed feasibility with respect to other economic indicators. Potentially ITMOs are cost-effective as they can reduce global abatement costs by enabling countries to achieve their mitigation targets by financing emissions reductions in other countries where abatement costs are lower (Mehling, Metcalf, and Stavins 2018; Warnecke et al. 2018). However, there may be substantial transaction costs as well-functioning carbon markets require investment in legal, administrative and monitoring systems (Kreibich and Schell, 2023). Further, the employment and productivity effects of ITMOs remain ambiguous. ITMOs can benefit selling countries by attracting foreign direct investment (FDI) and providing access to climate finance, leading to infrastructure development, job creation, and economic growth. However, the creation of new jobs may or may not offset job loss in the fossil fuel sector. The overall impact on the country hosting ITMOs projects depends on the specific policy pathway adopted and how it addresses job losses. Similarly, based on the experience of the EU-ETS it may be argued that productivity could either be hindered by firms reallocating resources or boosted by innovation, depending on how ITMOs drive climate policies (Koch and Themann, 2022). The study on the EU-ETS suggests that less advanced firms may experience efficiency losses due to regulatory costs, more advanced firms often see productivity gains, aligning with the hypothesis that environmental policies can spur innovation.

ITMOs can have an advantageous influence on geo-physical dimensions of feasibility. As they allow for increased flexibility in mitigation and technology transfer (Jiang et al. 2023), they can lead to more cost-effective mitigation and decrease challenges related to local physical constraints and the use of scarce (geo)physical resources. Similarly, ITMOs can contribute to the availability of land and its efficient use on a global scale. A model study that explored cooperative mitigation, found that large sellers had significant land resources, while regions with relatively little land available became buyers (IETA, 2021). Furthermore, Switzerland, Ghana and Vanatu engaged in the first ITMO projects, which involved sustainable rice practices and improved mitigation potential of existing land areas (UNDP, 2022). However, on a country level, it may also be argued that the influence of ITMOs on land availability is disadvantageous for a selling country, as the country may sell mitigation outcomes based on land they could have used for other purposes.

Financing emission reduction projects through ITMOs can facilitate the development of technologies in areas which would otherwise have no financial capacity or interest to do so, stimulating demand for low-carbon technologies and therefore their scalability. This relates to the fact that trading improves cost-efficiency. In theory, trading stimulates demand and therefore technological maturity. In practice, various dynamics can arise. Trading is cost-efficient but it might hinder innovation for the importer if not complemented by appropriate internal innovation policy (i.e. subsidies), thereby decreasing maturity. Similarly, while trading can stimulate simpler and proven technologies like afforestation over risky and complex options like direct air capture, it can also hinder innovation for the importer and thereby decrease the simplicity of technological options (Burke and Schenuit, 2024). The impact of ITMOs upon technological risk is ambiguous. On the one hand, in theory trading improves cost efficiency and therefore reduces risk of global policy failure. In practice, high risk of low quality removal and poor MRV/'outsourcing' of trade-offs (e.g. biodiversity loss) to other countries with lower environmental standards all increase risk of climate change and other areas of risk.

The performance of ITMOs on several social cultural dimensions of feasibility is also mixed. Evidence from carbon pricing literature seems to suggest that public ITMOs may or may not be publicly acceptable, with concerns over fairness and trust potentially causing backlash in certain countries (Mohammadzadeh Valencia et al. 2024). Similar to carbon pricing, the design of compensation schemes and perceptions of justice will play a key role in domestic acceptability of ITMOs (Klenert et al. 2018). ITMOs have the potential to offer significant co-benefits, such as improvements in air quality, biodiversity, and energy security, which can enhance their social value. Distributional effects of implementing ITMOs is potentially mixed, with outcomes depending on revenue recycling mechanisms and trading relationships between countries. Inclusiveness will be contingent on developing robust frameworks, putting in place safeguards to ensure ITMO projects support sustainable development, equitable participation and benefit sharing between and within countries (Re, Ellis, and Greiner 2022).

As far as institutional indicators are concerned, while engaging in ITMOs is voluntary, the political acceptability of ITMOs can vary significantly between countries based on national interests, equity concerns, and issues surrounding transparency and fairness of participating in ITMOs trading (IISD 2019; IISD 2023). Some countries may be more willing to embrace market mechanisms to enhance climate action, while others may prefer regulatory or non-market approaches. Participation in ITMOs can come with high transaction costs for some countries, as it requires the establishment of domestic rules and regulations, legal frameworks, along with administrative capacity for monitoring, reporting, verifying and authorizing ITMOs to ensure environmental integrity and prevent double counting. This can pose challenges for low- and middle-income countries, potentially deterring their participation (Kreibich and Schell 2023). At the bilateral level the feasibility of ITMOs depends on strong transparency and accountability frameworks to ensure projects are developed and implemented and mitigation outcomes are authorized and corresponding adjustments are made transparently (Michaelowa et al. 2020; Schneider and La Hoz Theuer 2019; Warnecke et al. 2018). Further, ITMOs require cross sectoral coordination for effective design, implementation, and monitoring which can impose high transaction costs especially on low and middle income countries. The lack of such coordination impedes the feasibility of ITMOs.

The geopolitical costs and benefits of ITMOs for buying and selling countries are complex and is effected by the power dynamics between the buying and selling countries. Countries purchasing ITMOs gain flexibility in meeting climate targets and lower compliance costs, while sellers can gain access to investments, revenue, capacity building and technical know-how. However, these transactions carry risks. Risks for buying countries include excessively heavy reliance on purchasing ITMOs rather than implementing necessary domestic emissions reductions. This over-dependence can result in missed opportunities for domestic job creation and industrial growth, potentially hindering long-term economic transformation. Costs for selling countries include risk of overselling ITMOs leaving them with less or more expensive options to meet their NDC targets (Kreibich and Schell 2023; Spalding-Fecher and Marcu 2022). The negotiation process for sharing ITMOs relies heavily on the power dynamics and bargaining power of trading partners involved. This interplay can affect the terms and conditions under which ITMOs are exchanged, leading to potential disparities based on the relative bargaining power of each party. Typically, buying countries aim to maximize their share of ITMOs, for the selling countries the challenge is to ensure that they do not compromise achieving their NDC by overselling mitigation outcomes (Kreibich and Schell 2023). Finally, while ITMOs require voluntary bilateral agreements between countries, common rules and standards established through the UNFCCC process are important enabling these agreements.

Carbon removals

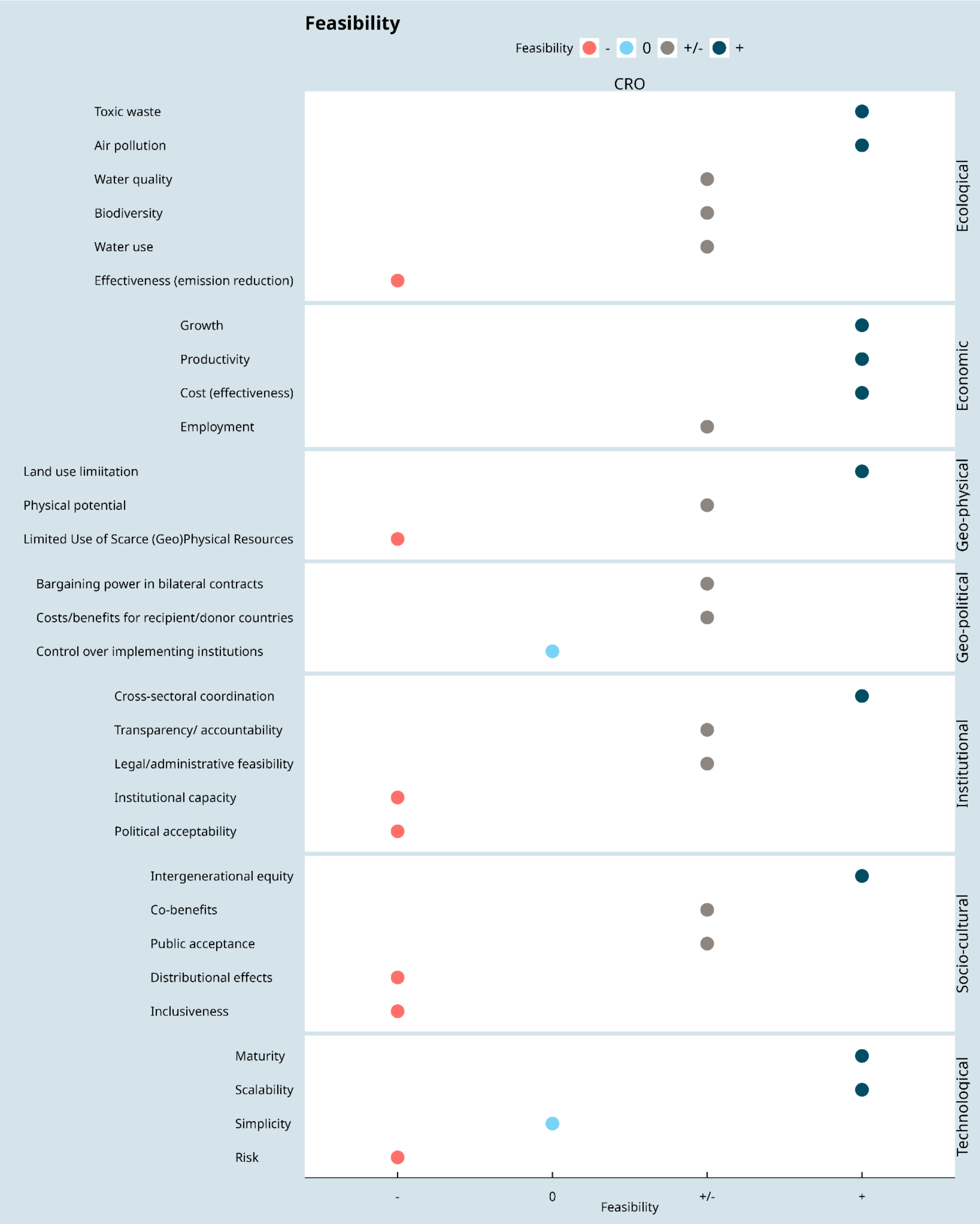

Figure 2 – Impacts of the introduction of CRs

With respect to the ecological indicators that pertain to the feasibility of CRs, the effects are deemed mostly uncertain or damaging. In relation to the effectiveness of

GHG removal, CR activities may negatively impact emission reduction efforts as they primarily focus on CO_2 removal rather than directly reducing emissions. However, literature suggests that CR activities have the potential to decrease unabated emissions, thereby contributing effectively to the mitigation of global warming. That said, in the short term mitigation may be neglected due to the possibility of future abatement. Therefore only abating emissions instead of ensuring GHG emission reductions is at the source of the problem (Jenksins et al., 2021; McLaren et al., 2019; Fuss et al., 2016). Specifically, for air pollution, some CR methods such as Bioenergy with Carbon Capture and Storage (BECCS) are generally equipped with end-of-pipe air pollution controls that effectively reduce air pollution. However, other technologies such as Direct Air Capture (DACCS) may not offer any co-benefits in terms of air pollution reduction. Additionally, CO_2 removal technologies could potentially hinder fossil fuel mitigation by providing an alternative pathway with minimal benefits for air pollution reduction. Lastly, while afforestation may have positive effects on certain air pollutants, it may also lead to the emission of organic air pollutants (Marmureanu, et al, 2014; Gustafsson et al., 2024; Rochelle, 2024). Similarly, with respect to toxic waste, some carbon removal methods such as CCS, ocean based solutions and enhanced weathering involve the use of chemicals, such as amines, heavy metals (in the case of bioenergy with carbon capture and storage) or fertilizers (Rochelle, 2024; Shahbaz et al., 2021; Williamson et al., 2012).

As far as water use, biodiversity and water quality are concerned, carrying out CR activities and the introduction of CROs can have varying impacts depending on the carbon removal method that is used. Accordingly, agroforestry, BECCS and enhanced mineralization that can be undertaken through engagement in mining increase water use (Nair, P. et al., 2010; American University b, 2020; American University e, 2020; Safe Drinking and Water Foundation, 2024). The use of biochar and soil carbon sequestration decrease water use (American University c, 2020; Ghimire, R., 2022). DACCS may increase or decrease water use depending on the technology that is used (Lebling et al., 2022). Agroforestry, soil carbon sequestration that reduces the use of fertilizers and biochar increase biodiversity (Moya, 2023; American University a, 2020; American University f, 2020; Keena et al., 2022). BECCS and DACCS decrease biodiversity (Dooley et al., 2020; American University b, 2020). While enhanced mineralization would increase biodiversity, mining activities that need to be carried out for this purpose would decrease biodiversity (Torres et al., 2024; American University e, 2020; IUCN, 2022). Lastly, while agroforestry, soil carbon sequestration that decreases the use of fertilizers and biochar increase water quality (American University a, 2020; American University f, 2020; Keena et al., 2022; Dong et al., 2023), BECCS that drives fertilizer use, enhanced mineralization and DACCS decrease water quality (American University b, 2020; Keena et al., 2022; American University e, 2020; American University d, 2020).

When evaluated through several indicators, including cost-effectiveness, employment impacts, productivity, and growth potential, the economic feasibility of CROs is mixed. Theoretically, depending upon the burden sharing principles applied, some regions and countries would have to deploy significantly more negative emissions at the time of global net-zero (Bednar et al. 2024; Lee et al. 2021). In principle, as mentioned in Section 4, there are two options have been proposed to enable for countries to remove adequate amounts of carbon from the atmosphere and fulfil their CR obligations: either they could deploy CR activities domestically, or they could pay for CRs abroad by recurring to an international CDR market. The latter option involves the establishment of a market for carbon removal by creating tradable obligations, which incentivize investments in carbon dioxide removal (CDR) technologies where they are most cost-effective. However, creating a CDR market comes with several costs and risks. Lee et al. (2021) argue that if countries were to use CDR units to reach their net-zero targets without shifting their targets forward in time, essential domestic emission reductions could be compromised. Furthermore, they warn that transferring CDR could act as a mitigation deterrence, prolonging the use of fossil fuels and discouraging investments in clean energy (McLaren and Markusson 2020). Additionally, international CDR transfers on a large scale may come with a risk of substantial carbon loss, meaning that the amount of promised CDR units promise are not fully delivered (Lee et al. 2021). Other studies have also noted the risks of international carbon markets or including carbon removals in existing emission trading systems, as the predominant policy lever for CDR (Burke and Gambhir 2022; Cox and Edwards 2019). Burke and Gambhir (2022) argue that carbon markets alone may not create the necessary demand to drive the deployment of more expensive CDR technologies, such as direct air capture BECCS, to a commercially viable scale. These technologies, while scalable, remain costly, and market forces may not be sufficient to bring them down the cost curve without additional policy support. Moreover, introducing lower-cost CDR options, such as nature-based solutions, into carbon markets too early could depress the overall carbon price, especially if emissions caps are not adjusted accordingly. This could undermine the economic incentives needed to scale both technological and nature-based CDR. Together, this implies that the employment effects of CROs vary depending on the carbon dioxide removal (CDR) technologies used; for instance, land-based approaches like afforestation may generate low-paid, seasonal jobs, with overall impacts influenced by the governance of CDR initiatives (Carton et al. 2020). Additionally, if CR activities allow fossil fuel industries to operate longer than expected, this could stabilize employment in the short term but may also hinder the transition to cleaner energy. Finally, while CRs could stimulate investments in CDR and foster innovation and economic growth, they may also prolong the operational lifespan of fossil fuels, conflicting with long-term climate goals.

The impact of geophysical indicators on the feasibility of CROs is contingent on the specific indicator and lacks a discernible pattern. The removal of carbon dioxide from the atmosphere reduces the concentration of this greenhouse gas, which can result in a cooling effect on the planet. Carbon removals offer a potential avenue for achieving temperature targets through an overshoot. Nevertheless, the physical potential of carbon removal is constrained by the technological capacity available. Furthermore, this only applies to the removal of CO_2 and not to other greenhouse gasses, which limits the potential of the policy (Bednar et al., 2024). One potential challenge to the feasibility of the policy is the risk of leakage and limited effectiveness over time associated with carbon storage (Haszeldine, 2009; Gibbins and Chalmers, 2008). In light of these considerations, the physical potential remains ambiguous. The implementation of large-scale CO_2 removal through technologies such as bioenergy with carbon capture and storage and afforestation has the potential to significantly impact land use. As highlighted by the IPCC (IPCC, 2019), future competition for land could give rise to conflicts with food production or biodiversity conservation. This has the effect of negatively impacting the feasibility of the policy. If available land for carbon removal is limited, there is overall less potential for large-scale carbon removal. Technologies such as DACCS are energy-intensive, and regions with limited access to renewable energy or water may find these technologies less feasible (Gibbins & Chalmers, 2008). As demonstrated by studies such as Fuss et al. (2018), the energy footprint of carbon removal can negate its benefits unless powered by carbon-neutral energy sources. The scarcity of these resources in certain regions imposes constraints on the scalability and effectiveness of CROs, thereby complicating the implementation of such policies on an equitable global scale.

The interaction of CROs with technology mainly relates to the development of CDR. Since CROs legally bind companies that generate a carbon debt to remove a corresponding amount of carbon in the future, they create certainty of future CDR demand. This should facilitate the scalability and maturity and decrease risk of CDR options as expectation of future demand is fundamental for stimulate investment and innovation (Campiglio et al., 2024). On the other hand, CROs have no relevant effect on technological simplicity.

The direction for socio-cultural indicators of feasibility of CROs is also mixed. Large-scale CDR deployment may be perceived negatively by stakeholders and broader public audiences (Low et al. 2024) hampering the creation of CDR market for meeting CRO. Reasons for lack of public acceptance or negative perception encompass offering too slow a response to climate change, not addressing the root cause of climate change, deterring fossil fuel phase-out and risk of leakages. Furthermore, Lee et al. (2021) argue that there is limited evidence of co-benefits from technological CDR options as compared to emission reductions, and deployment at large-scale could generate adverse impacts and distributional consequences, especially when their full life-cycle is considered (Honegger and Reiner 2018). Similarly, while land-based CDR measures may have co-benefits, they may also be associated with trade-offs with environmental, social, and economic objectives. For example-land based CDR may have trade-offs with food security, agricultural productivity, livelihoods, land rights of local communities and indigenous peoples (Carton et al. 2020). As far as intergenerational equity is concerned, if CDR remains primarily a motivation for reducing net present costs by accrual of carbon debt, then it will further burden the future generations. Others have called for further discussion to understand the role of direct air capture in a way that respects inter-generational equity and reduces moral hazard (Burke and Gambhir 2022).

The institutional indicators of feasibility of CROs present a mixed picture and require careful attention to legal frameworks, administrative capacities, and transparent governance. From a legal and administrative perspective, some have argued that the feasibility of CROs hinges on the effective integration of carbon removal into international frameworks like the Paris Agreement’s Article 6 (Fajardy and Mac Dowell 2020; Lee et al. 2021) . However, significant governance challenges remain, especially around tracking and verifying the progress of carbon removal efforts. The lack of a uniform accounting framework across the entire lifecycle of CDR projects, as well as uncertainties in measurement and risk of non-permanence particularly for land-based CDR present serious risks to transparency and accurate reporting (Lee et al. 2021). Others have called for maintaining a clear distinction between emissions reduction and CDR targets (Carton et al. 2021; McLaren et al. 2019), and disallowing land-based CDR to enhance transparency and accountability (Lee et al. 2021).

Institutional capacity is another crucial consideration. Burke and Gambhir (2022) note that a multi-faceted governance approach would be required to ensure that carbon markets complement other mechanisms, such as targeted innovation policy support, for driving CDR development. Similarly, Honegger et al. (2021) argue that different CDR approaches might initially need differentiated treatment based on their differing maturity and cost through R&D pilot activity subsidies. Further, they suggest that in the longer term, CDR increasingly ought to be funded through mitigation results-oriented financing and included in broader policy instruments. Political acceptability of CDR is highly influenced by concerns about delaying mitigation activities in favour of future CDR, the risks of carbon lock-in, and the potential for social and environmental conflicts. Political acceptability is also intertwined with equity issues, particularly when countries pay for CDR abroad, as this may raise concerns about fairness and the distribution of responsibilities (Lee et al. 2021). Cross-sectoral coordination between various sectors participating in implementation of CDR, and monitoring, verifying and reporting is required pre-condition for CROs to be feasible.

The geopolitical feasibility of CROs is deeply tied to questions of equity, fairness, and international cooperation, especially as the global community seeks to meet net-zero targets through both domestic efforts and international mechanisms. Currently, how to account global CDR obligations towards national net-zero targets is under discussion and their allocation remains an open question. The costs and benefits for nations would, therefore, depend upon the burden-sharing principle applied and the framework and rules and regulations of the engagement in the carbon market for CDR. At the international level, there is currently no institution with the mandate to enforce CROs or sanction countries in the case of non-compliance. Some have suggested incorporating CDR into Article 6 as a means to promote equitable deployment (Fyson et al. 2020; Pozo et al. 2020). This approach could accelerate technology transfer and provide international financial support for CDR initiatives in countries with fewer resources or lower historical responsibility for emissions. Simultaneously, it could motivate larger CDR commitments from major historical emitters. The international framework will also determine how countries approach bilateral bargaining to remove carbon to meet the CROs and the control exercised by implementing agencies.

L&D initiatives

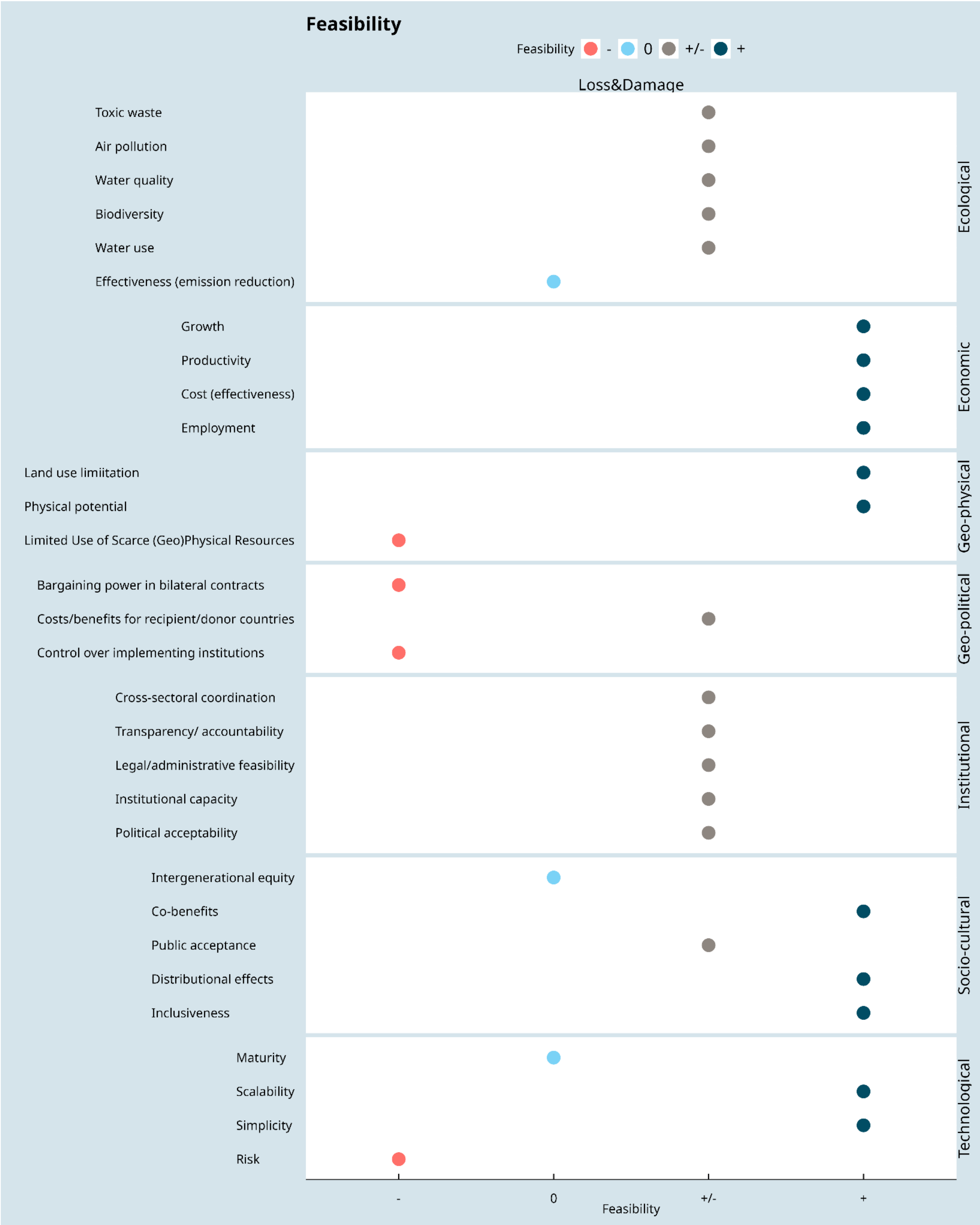

Figure 3 – Impacts of the introduction of L&D initiatives

With respect to the environmental indicators, the resulting outcomes are somewhat disconnected, as they relate directly to adaptation and not to mitigation. Therefore, it is difficult to insert a sign. Initiatives addressing economic L&D redress harm suffered by agricultural products, dwellings and infrastructure. Therefore, they do not directly impact emission levels. In addition, initiatives addressing environmental L&D do not directly impact emission levels. Similarly, as initiatives addressing economic L&D redress harm suffered by agricultural products, dwellings and infrastructure, they do not directly impact air pollution levels (LSE Grantham Research Institute on Climate Change and the Environment, 2022). That said, initiatives addressing environmental L&D can reduce air pollution via technical assistance (UN Climate Change, 2024). Steps that are taken as part of some initiatives to revitalize the agriculture sector can lead to the generation of toxic waste if the relevant safeguards are not observed (LSE Grantham Research Institute on Climate Change and the Environment, 2022; UNEP, 2024). Conversely, initiatives addressing environmental L&D can reduce toxic waste via technical assistance (UN Climate Change, 024).

As far as water use, biodiversity and water quality are concerned, steps that are taken to revitalize the agriculture sector and rebuild dwellings and infrastructure as part of initiatives addressing economic L&D can increase water use (Walker, 2022; LSE Grantham Research Institute on Climate Change and the Environment, 2022; European Commission, 2024) and decrease biodiversity (CIC, 2024; National Academy of Sciences and The Royal Society, 2021; LSE Grantham Research Institute on Climate Change and the Environment, 2022) and water quality (LSE Grantham Research Institute on Climate Change and the Environment, 2022; Turnbull and Cordeaux, 2023; Ongley, E., 1996). On the other hand, initiatives addressing environmental L&D can reduce water use and enrich biodiversity and water quality via technical assistance (UN Climate Change, 2024).

L&D initiatives present varying levels of feasibility across economic, socio-cultural, institutional, and geopolitical dimensions. Economically, while the upfront costs of these initiatives can be high, their long-term cost-effectiveness may be significant but difficult to monetize. Investing in preventive measures and resilient infrastructure helps mitigate the financial impacts of climate-related disasters, reducing the need for repeated disaster relief, lowering insurance costs, and minimizing broader economic disruptions (Tavoni et al. 2024). However, accurately determining this cost-effectiveness is complex, as both financial return on investment as well as less tangible social and environmental gains need to be taken into account (Boyd et al. 2021). In regions where livelihoods are deeply tied to climate-vulnerable sectors, such as agriculture or tourism, the failure to adequately address loss and damage could lead to job displacement and economic instability (Birkmann et al. 2022). As L&D initiatives often involve rebuilding and improving communities affected by climate change, they can create jobs for example in construction, green technology, and ecosystem restoration. Moreover, these initiatives protect critical infrastructure and livelihoods, which stabilizes productivity and economic growth. Governments are likely to support L&D measures as they help minimize the negative effects of climate disruptions, ensuring long-term economic stability.

L&D is not directly related to a set of technologies, as it refers to financial compensation which does not necessarily imply technology-based projects. However, L&D initiatives can decrease technological risk if they finance the rebuilding of more resilient infrastructure after a catastrophic event. Furthermore, because L&D recipients are mostly low income countries, simpler technologies and techniques that require less infrastructural coordination and are easier to implement (for example, passive cooling in buildings) could be more effective and acceptable. In this sense, L&D might and should favor technological simplicity (Kotz et al., 2024; Gilli et al., 2024). As for scalability of technology, L&D initiatives could favor the spread and scalability of certain technologies if the financial compensation is spent in projects to increase resilience or adaptive capacity of infrastructure. L&D initiatives do not impact the maturity of the technological options.

From a socio-cultural perspective, public acceptance of L&D initiatives is mixed. While countries especially vulnerable to climate change such as small island states and those facing adverse socio-economic impacts from extreme events generally welcome loss and damage finance, for donor countries it may be challenging to mobilize funds (Åberg and Jeffs 2022). Despite these challenges, L&D initiatives could offer co-benefits, especially for adaptation. They often foster innovation in disaster risk reduction, promote sustainable infrastructure and enhance community-level adaptation strategies. These efforts contribute to broader socio-economic stability, improving public health and preserving ecosystems. Losses and damages are most felt by poor, vulnerable and marginalized communities (Birkmann et al. 2022). Therefore, undertaking measures to minimize loss and damage that especially target vulnerable populations will improve inclusiveness. In terms of intergenerational equity, the impact of L&D initiatives is neutral. These efforts may address or remedy the harm caused by insufficient past mitigation and adaptation measures but do not necessarily improve future prospects. However, they have a positive effect on distributional equity by directing resources to vulnerable populations and integrating climate justice into broader policy frameworks (Boyd et al. 2021).

Institutionally, the feasibility of L&D initiatives faces several challenges. Political acceptability is mixed especially among countries expected to provide financial support to undertake such initiatives in developing countries due to polarized opinions on liability issues (Tavoni et al. 2024). Countries experiencing climate-related losses tend to be more supportive, while donor countries often resist such initiatives as they are concerned about the implications of financial responsibility. Legal and administrative feasibility is enhanced when L&D is incorporated into international agreements and national laws, such as disaster risk reduction plans, building codes, and insurance regulations (Boyd et al. 2021). However, effective implementation depends on the administrative capacity of local governments, which can vary significantly (IIED 2013). Strong institutional capacity is crucial for L&D initiatives to succeed, as it ensures that resources are directed efficiently and policies are developed effectively (Boyd et al. 2021). Conversely, weak institutions can lead to mismanagement and ineffective outcomes. Transparency and accountability are also key considerations. Transparency is essential to ensure that funds are used effectively. Cross-sectoral coordination is another challenge, as L&D initiatives require collaboration across multiple areas, including finance, infrastructure, and environmental policy (IIED 2013, 2022). Achieving such coordination can be difficult, but it is necessary for the successful implementation of these initiatives.

Geopolitically, L&D initiatives face significant hurdles. For recipient countries, the benefits of receiving funding are clear, but donor countries often view these contributions as a financial burden, making them resistant to committing resources. Further, the topic's association with historical responsibility of developed countries for causing climate change linked with calls for them to provide compensation to developing countries makes the topic controversial in international negotiations as some developed countries remain apprehensive about liability and compensation (Åberg and Jeffs, 2022; Falzon et al. 2023). This dynamic potentially affects the bargaining power of recipient countries in bilateral negotiations. While they may wield some soft power through moral or diplomatic influence, wealthy donor countries generally hold more leverage. Additionally, control over the implementation of L&D funds remains uncertain. The Loss and Damage Fund established by the Conference of the Parties (COP) is still in the process of being structured, leaving unresolved questions about who will contribute funds, who will receive them, and how they will be managed (Serdeczny and Lissner, 2023).

Geophysically, L&D initiatives can inarguably have a beneficial effect on the physical potential of recipient countries to withstand the impacts of climate change as they provide them with the ability to construct sea-walls, take flood prevention measures and revert land loss due to erosion or desertification etc. (United Nations, 2024; Addison et al., 2022). Similarly, loss and damage initiatives can combat land-use limitations not just by reversing land changes brought about by climate change (e.g. desertification) but in the literal sense as well - recover land loss due to erosion, sea level rise, wildfires etc., especially in vulnerable areas such as Bangladesh or small island states (Bhandari et al., 2024; PEDRR and FEBA; UNEP, 2016; Srivastava et al., 2024). However, widespread adaptation of L&D initiatives can have an adverse impact on resource use. Beyond the funding/financial flows, efforts to protect or reclaim/regenerate land and create long-term, resilient infrastructure can be intensive in terms of geophysical resources required (UNFCCC, 2024; PEDRR and FEBA, 2024; UNEP, 2016; Srivastava et al., 2024).

In conclusion, while loss and damage initiatives offer clear economic, social, and environmental benefits, they face significant challenges in the political, institutional and geopolitical arenas. Their feasibility depends heavily on strong institutional capacities, equitable governance structures, and international cooperation between donor and recipient countries.

7. Conclusions

We provide the first comprehensive assessment of the political feasibility of three international climate policy initiatives: internationally transferable mitigation outcomes (ITMOs), carbon removal obligations (CROs) and loss and damage (L&D) initiatives. We assess enabling factors as well as barriers along seven categories, including ecological, economic, geo-physical, geo-political, institutional, socio-cultural, and technological, each supported by multiple indicators. Our results give a nuanced and consistently comparable picture of how different initiatives compare.

The feasibility assessment of the three policies - CRO, ITMO, and L&D - displayed in Figure 4 reveals distinct patterns across ecological, economic, geopolitical, institutional, socio-cultural, and technological dimensions. ITMOs stand out for their significant variability in feasibility rankings, often depending on whether a party is acting as a buyer or seller of mitigation outcomes. This suggests a high degree of uncertainty and the need for tailored governance mechanisms to ensure equitable and effective outcomes. For instance, ecological indicators such as water use and biodiversity show uncertain feasibility, while economic indicators like cost-effectiveness exhibit positive signs for feasibility, reflecting the complexity of market-based mechanisms.

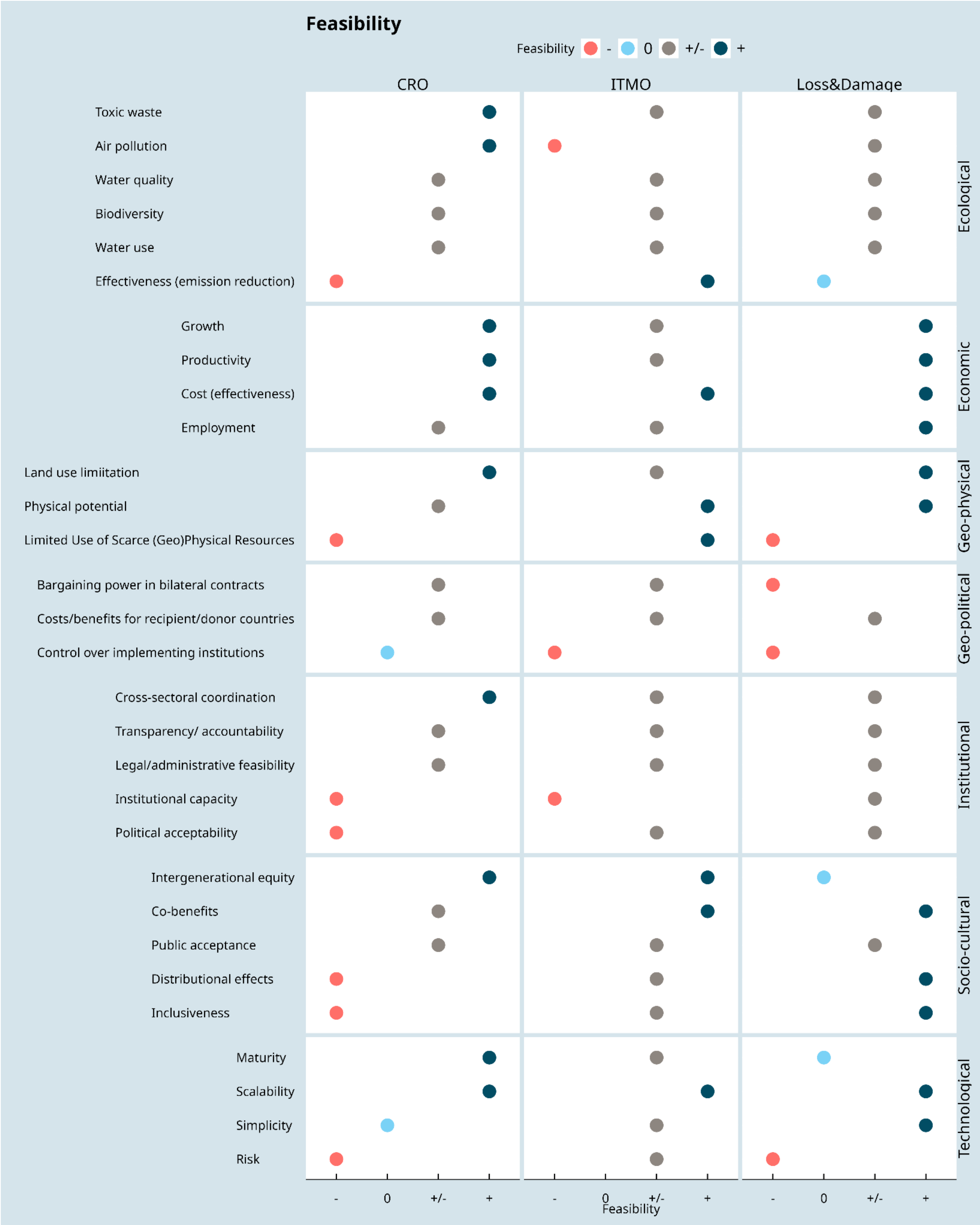

Figure 4 – Feasibility assessment of ITMOs, CROs and L&D initiatives

We find considerable differences regarding the evaluation of the political feasibility of different options (Figure 5). In Figure 5, negative impacts of a given initiative have been identified as barrier while their positive impacts have been presented as enablers.

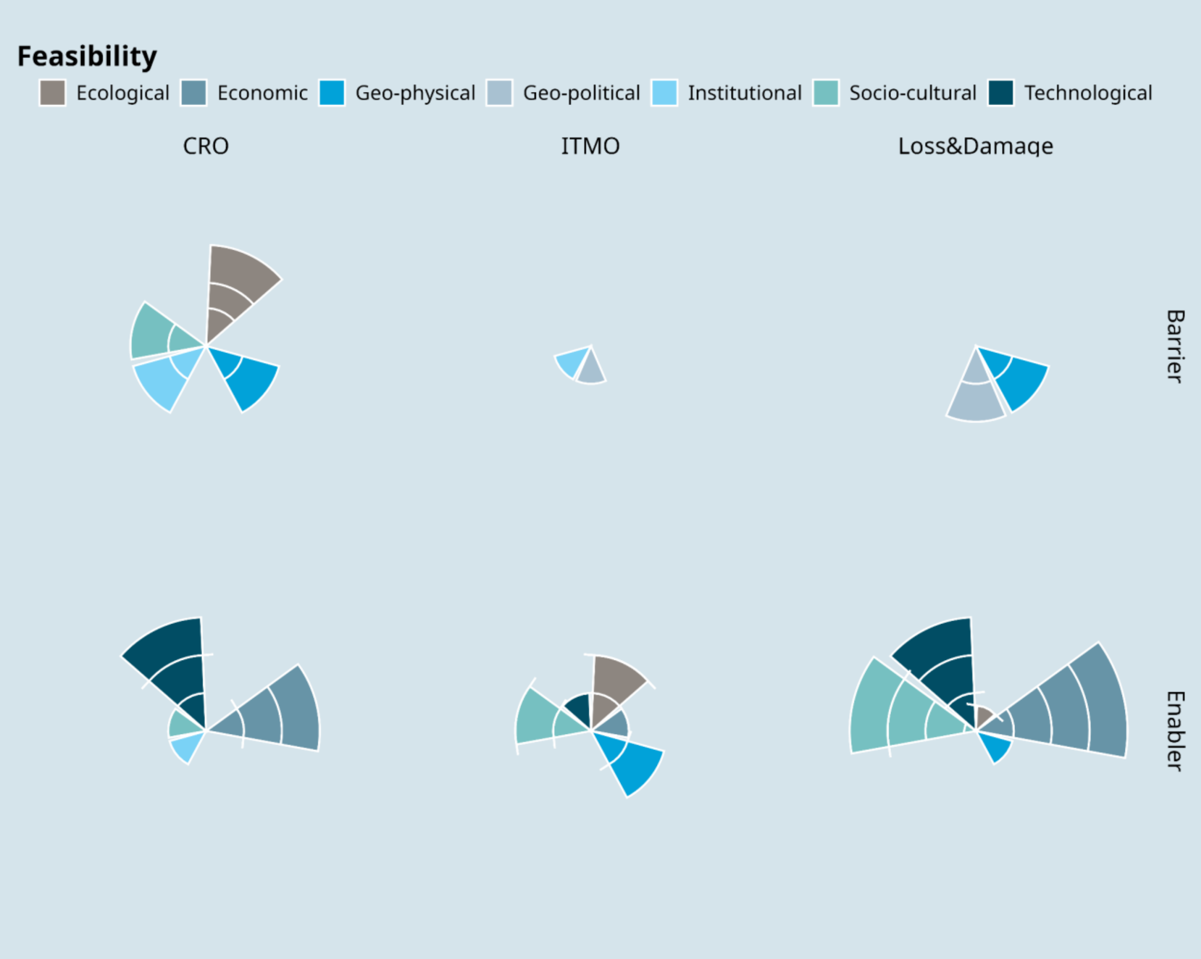

Figure 5 – Political feasibility of ITMOs, CROs and L&D initiatives

L&D, based on our methodology, seems to show strong enabling factors in terms of feasibility, particularly in geopolitical, technological and economic dimensions. The feasibility of CROs seems to be more constrained despite the presence of technological and economic enablers. This can mainly be explained by ecological, geopolitical, institutional and social-cultural barriers. On the other hand, CROs show high-tech and economic feasibility enablers but face major ecological barriers. ITMOs' feasibility is ensured by ecological, geophysical, and socio-cultural dimensions; yet, we find that particularly for ITMOs the feasibility is highly dependent on the specific country context and cannot not clearly be assessed in a fully generalizable pattern. Generally, country-specific constraints will be decisive for the feasibility of specific initiatives from a political economy perspective and their contribution to international mitigation efforts.

CROs display strong feasibility in technological aspects, particularly scalability, indicating that it might be easier to implement from a technological standpoint. However, it faces challenges in areas such as political acceptability, inclusiveness and risk, where it ranks negatively, pointing to potential governance and societal hurdles. Meanwhile, L&D governance mechanisms display more neutral and balanced feasibility across several dimensions, particularly in terms of geopolitical and socio-cultural factors, suggesting that while it may be socially feasible, there are still uncertainties in its broader implementation, such as institutional capacity and the geopolitical aspects.

Our results can however help to identify key questions that need deeper discussion when it comes to the introduction of international climate policy initiatives. While economic and technological factors usually contribute positively to the feasibility of initiatives, other dimensions, such as geopolitical, ecological and geophysical might influence negatively the politics of climate policy. In this context, L&D stands out as the most feasible option, with many socio-cultural enablers and relatively low barriers across multiple domains. That said, it faces major geopolitical barriers.

As far as ITMOs are concerned, the outcome of our assessment can provide guidance to states that are either negotiating or preparing bilateral agreements or implementing them (UNEP, 2024). Similarly, our evaluation with respect to CRs can shape efforts geared towards the establishment of domestic regulatory frameworks governing CROs (Bednar et al., 2023) and an international CDR market (Lee et al., 2021). Lastly, given that current financial flows are way lower than the cumulative amount that is needed for meeting the exigencies of all countries suffering from climate change related loss and damage (Wenger and Johnson, 2023), our conclusions can help countries that transfer and receive funds as part of L&D initiatives to contribute to and benefit from initiatives that have the highest amount of enablers and lowest amount of barriers.

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