Current understanding of the potential impact of Carbon Dioxide Removal approaches on the Sustainable Development Goals in selected countries in Latin America and the Caribbean

Summary for policy makers

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Current understanding of the potential impact of Carbon Dioxide Removal approaches on the Sustainable Development Goals in selected countries in Latin America and the Caribbean. Summary for policy makers.

This document was produced under the coordination of Joseluis Samianego, of the Economic Commission for Latin America and the Caribbean (ECLAC) and Kai-Uwe Schmidt, of the Carnegie Climate Governance Initiative (C2G). Hernan Carlino, Luciano Caratori, Micaela Carlino, Agustín Gogorza, Alfonso Rodríguez Vagaría and Gabriel Vazquez Amábile, from the Torcuato Di Tella Foundation participated in its elaboration. The authors thank the following people for their comments, suggestions, revisions and contributions to the document: Estefani Rondón, José Javier Gómez and Jimy Ferrer, from ECLAC, Nicholas Harrison, Alia Hassan and Michael Thompson, from C2G.

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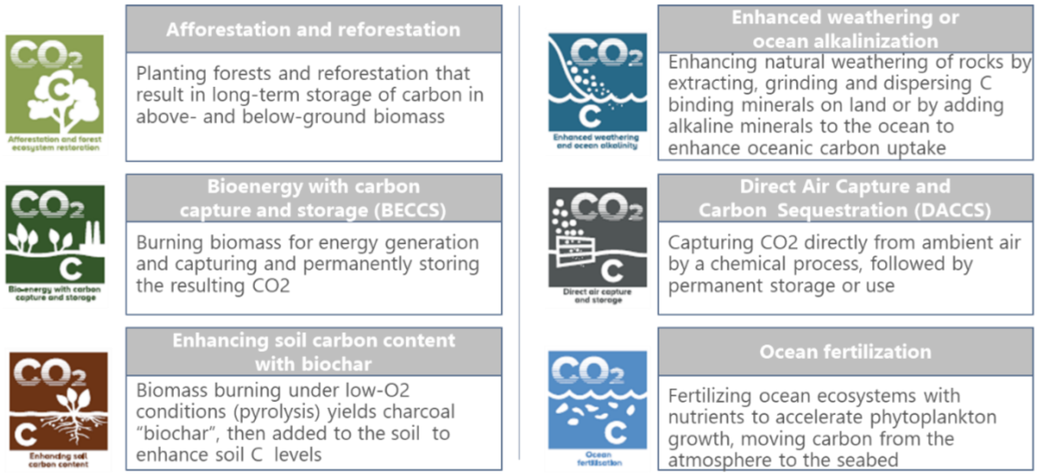
Summary for policy makers

The report "Current understanding of the impact of Carbon Dioxide Removal (CDR) approaches on Sustainable Development Goals (SDGs) in selected countries in Latin America and the Caribbean" responds to a request made in late 2020 by the Carnegie Climate Governance Initiative (C2G) and the Economic Commission for Latin America and the Caribbean (ECLAC). CDR approaches were considered, after C2G categorization and IPCC definitions.

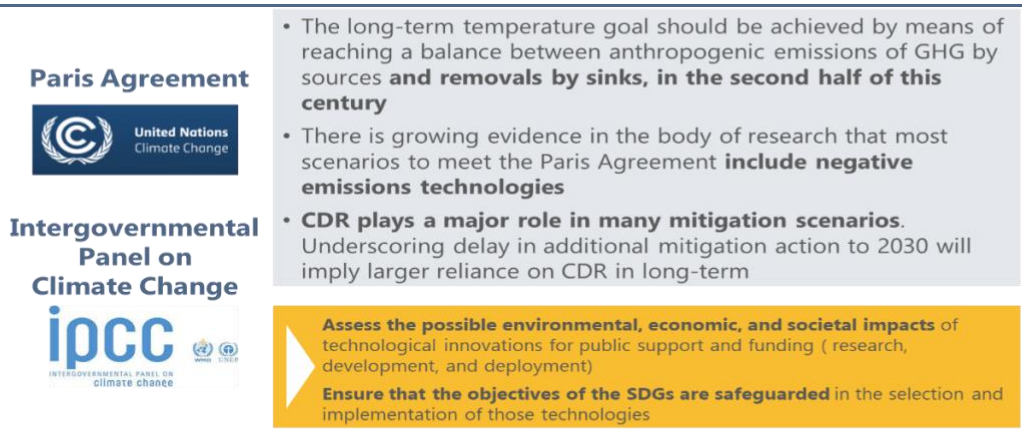
Figure 1: *Classification of Carbon Dioxide Removal approaches*



Source: C2G (2018). Honegger, M. et al. Carbon Removal and Solar Geoengineering Potential implications for delivery of the Sustainable Development Goals. C2G2 Report. May 2018.

The references to the context in which the outcomes of the report should be broadly considered provide a very succinct characterization of major contextual elements from a scientific perspective, which might define the border conditions for the integration of those outcomes into a national climate policy stance.

Figure 2: *Relevant Context for the Study*



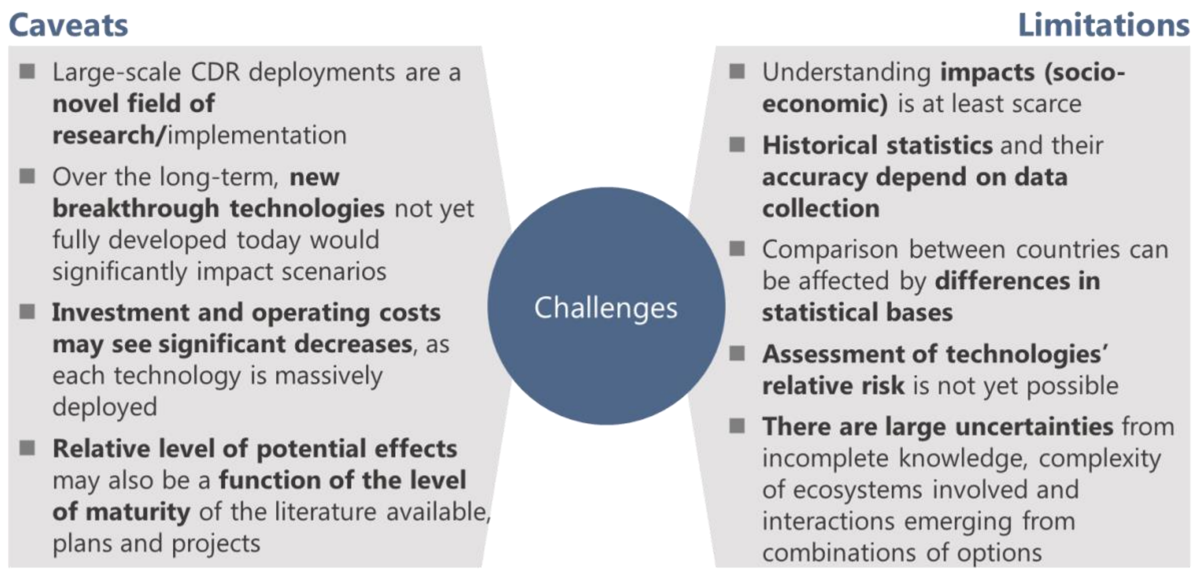
Source: Paris Agreement; IPCC AR5; IPCC Special Report on Global Warming; IPCC SPM (2018)

This report synthesizes the best understandings of potential implications of the adoption of nature-based and technical options for carbon dioxide removal, aiming to complement direct emissions reductions. The findings are based on the assessment of the available scientific, technical and socio-economic literature

and the economic, social and environmental implications of the implementation of CDR technological options. The implications are to be examined against the achievement of the Sustainable Development Goals (SDGs) and the contribution to climate mitigation that the implementation may have in Argentina and Colombia. This analysis helps to identify knowledge gaps and where possible formulate recommendations and specify options for consideration by governments in the region to decide and eventually stimulate the potential inclusion of relevant CDR approaches in national climate change strategies that contribute to the achievement of the SDGs, the Nationally Determined Contributions (NDCs) and green recovery plans, when applicable. The outputs can also be used to help showcase the need to undertake further research in order to reduce existing knowledge gaps and foster progress in scientific and technical information availability that would facilitate governments in the region making informed decisions.

The impact analysis faces certain challenges that might have effects in terms of its accuracy and level of confidence:

***Figure 3:** Limitations of the analysis*



Source: Own elaboration

This Summary for Policymakers (SPM) is structured in two parts: A) Key Findings; B) Recommendations on the potential deployment of applicable large-scale CDR approaches. An appendix is included with Recommended areas for further research.

A. Key findings of the study

Knowledge, planning and implementation gaps

In general, and with rare exceptions, a significant knowledge and empirical development gap of CDR has been identified in Latin American and the Caribbean (LAC) countries:

- LAC countries efforts on climate change mitigation are primarily focused, as is appropriate, on emissions reductions and replacement of fossil fuels production and use, and only in a largely incipient manner carbon removal efforts are being considered
- Deployment of large-scale CDR approaches would be expected to have physical side-effects and socio-economic or governance implications on the delivery of SDGs
- The broader implications of CDR technologies in contributing to delivering or hindering sustainable development efforts are so far insufficiently explored and understood, predominantly from a planning perspective
- LAC countries face a persistent climate finance gap, the decision on the potential development of those options would require accurate abatement costs information and careful consideration of implementation risks in order to avoid misallocation of resources
- A comprehensive research and technical development effort for each technology should be undertaken

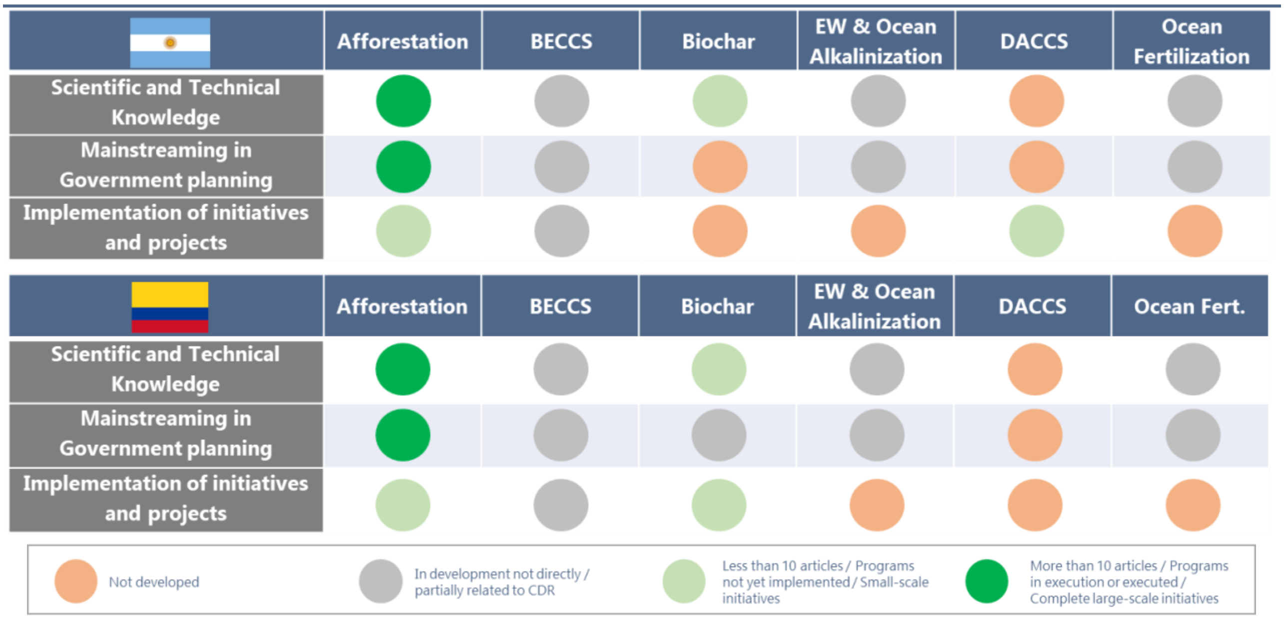
Afforestation and Reforestation and Enhancing soil with Biochar are the most explored CDR approaches in the scientific and academic field in LAC.

Figure 4: *Knowledge, planning and implementation gaps of CDR approaches in LAC countries*

Source: Own elaboration on the basis of review of information and rating

In particular for Argentina and Colombia, our own methodological approach was applied, building upon the C2G methodology [Honegger, et al 2018], and considering three different dimensions to determine the current status of: i) scientific and technical knowledge, ii) adoption in planning, and iii) empirical application of the selected CDR approaches in those countries.

Figure 5: *Current Status of Knowledge and Development in Argentina and Colombia - Scoring Methodology*



Source: Own elaboration on the basis of review of information and rating

Despite the fact that knowledge developed in LAC countries on DACCS is almost null, a qualitative analysis based on available international literature was performed:

- Given its early stage of development and the very limited number of empirical interventions, deploying the technology at scale seems to be still a considerable challenge, though both optimistic and pessimistic outlooks co-exist.
- In a transition to net-zero emissions, DACCS is presently one of a short number of technological options available to remove CO2 directly from the atmosphere.
- According to research done in the EU, DACCS cost needs to drop by at least an order of magnitude with respect to its value today for this option to become financially and economically feasible.
- DACCS needs to be demonstrated at a relevant scale, to reduce uncertainties regarding future deployment potential and costs.
  - Worlwide there are several DACCS plants (mainly pilot plants) with a combined capacity of less than 10,000 tons of CO2 per year. Locations include Europe, US and Canada, but none of them is located in Latin America.
  - The first large-scale DACCS plant (1 million ton CO2/ year capacity) is expected to start construction in US Permian basin not before 2022
- Large-scale demonstration of CDR technologies such as DACCS will require targeted government support.

Impact analysis - Argentina and Colombia

This section summarizes the estimation of the impacts of large-scale deployment of the selected CDR approaches in Argentina and Colombia, according to the scenarios determined. Several linkages among macro and intra-sectoral variables for each CDR approach and country were identified, estimating long-term impacts of CDR deployment on key variables contributing to the achievement of the SDGs.

Some CDR approaches covered in this study (like DACCS, Enhanced weathering, Ocean Alkalinization and Ocean Fertilization) were not examined in terms of deep-dive impact analysis due to lack of information for accurate modelling. In the near term, large-scale demonstration of such CDR technologies will require targeted government support .

Argentina impacts

- Adopting a deep decarbonization pathway in Argentina requires deepening efforts in key sectors by launching transitions primarily but not only in the energy, transport and Agriculture Forestry and Other Land Use (AFOLU) sectors. In this context, afforestation and reforestation constitutes a core mitigation strategy to reduce net emissions and ensure removal at a large scale. It is estimated that afforestation could remove an average of over 15 Megatons of CO2 equivalent per year (CO2e/yr) during the 2020-2050 period in a plausible scenario of a maximum of 80 thousand hectares planted per year. The implementation of this approach is consistent with decarbonization pathways envisaged by national climate policies.
- Afforestation and reforestation present the lowest cost per ton sequestered (~6 USD/tonCO2e) and the largest emissions removal for Argentina, and should be prioritized in the near term. In spite of its abatement low cost, the scenarios estimate investments of around 60-100 million USD/yr. and provide a significant source of direct employment. Larger investments, effects in employment and Gross Domestic Product (GDP) than estimated might be possible if the wood industrial value chain is significantly developed.
- Changes in livestock production practices, in particular those increasing soil carbon stocks can provide further means to rising mitigation ambition in the short to medium term.
- Similarly, changes in current but evolving agricultural practices (and thus technically and culturally feasible) can contribute to incremental emission reductions.
- The application of biochar on soils could sequester up to 2.5 Megatons of CO2e/yr. by 2050, considering only fruit trees. Further expansion to other intensive crops and later to extensive crops might be an upside to explore with further research and pilot projects. Moreover, biochar deployment exhibits the second lowest abatement cost.
- There is uncertainty about the feasibility of timely upscaling of BECCS. CCS is largely absent from the Argentinean NDC and lowly ranked in investment priorities. It is estimated that BECCS could sequester up to 2.0 Megatons of CO2e/yr. by 2050 with over 1,300 MegaWatts (MW) of additional installed capacity.

Table 1: *Impact of CDR deployment on key variables – Argentina*

		Potential GHG emissions (sequestered)	Avg Investment requirements	Cost	Net changes in employment created	Contribution to GDP
		Mega t CO2 /year	MM USD/yr	USD / t CO2	# jobs created/ Mega t CO2 seq	Δ MMUSD GDP / Mega t CO2 seq
Afforestation	Baseline	5.6 (avg) 7.7 (2050)	29 (avg)	5.1	73 direct 117 indirect	22
	Sc1	10.3 (avg) 11.3 (2050)	59 (avg)	5.6	80 direct 127 indirect	24
	Sc2	15.9 (avg) 14.4 (2050)	100 (avg)	6.1	85 direct 136 indirect	26
BECCS	Baseline	No CCS adoption in baseline scenario, only bioenergy				
	Sc1	0.1 (avg) 0.3 (2050)	35 (avg)	256.5	733 permanent 258 constr.	1,075
	Sc2	0.7 (avg) 2.0 (2050)	163 (avg)	239	1,037 permanent 360 constr.	1,000
Biochar	Baseline	No biochar deployment in baseline scenario				
	Sc1	0.1 (avg) 0.2 (2050)	3 (avg)	25.4	102 industrial	110
	Sc2	1.5 (avg) 2.5 (2050)	30 (avg)	19.3	77 industrial	84

Source: Own elaboration
MMUSD: million US dollars

- BECCS deployment in the mid-term implies large investments in capital intensive industrial facilities, and therefore exhibits high GDP and employment multipliers. However, BECCS is still an immature technology in Argentina with the largest abatement cost (240 to 260 USD/tonCO2e), among CDR approaches analyzed.

Colombia impacts

- Controlling deforestation is key for lowering national emissions. Further, given the need to produce additional food and biomass by intensifying agriculture and cattle production, halting deforestation emerges as an imperative to facilitate the adoption of a deep decarbonization and long-term sustainable food production.
- Afforestation also presents the largest Greenhouse Gases (GHG) emissions potential in Colombia, with an average of over 13 Megaton of CO2e/yr. in the 2020-2050 period.
- Colombia is one of the world's top 20 countries in terms of mangrove coverage, with nearly 300,000 ha of mangrove trees in the Pacific and Caribbean Coasts. Mangroves are well known for their high capacity to capture carbon stock per unit of land compared with terrestrial forests. It is expected that mangrove restoration at a 0.7% annual rate (58 thousand ha restored in the next 30 years) could sequester up to 3 Megaton of CO2e/yr., with relatively low investments and costs per ton of CO2.
- Effects in employment and GDP contribution of afforestation and mangrove restoration interventions might be underestimated if other indirect economic activities derived from its value chain and ecosystem respectively were also considered (not included in the figures below) beyond primary plantations activities.
- Only considering deployment in fruit tree plantations, Biochar application on Colombian soil could sequester up to 5 Megatons of CO2e/yr. by 2050. As mentioned in

Argentina, further expansion to other intensive crops and later to extensive crops might be an upside to explore with further research and pilots in Colombia. Although higher than Afforestation and Mangrove restoration, Biochar application cost per ton is expected to remain below 25 USD/ton CO2e.

Table 2: *Impact of CDR deployment on key variables – Colombia*

		Potential GHG emissions (sequestered)	Avg Investment requirements	Cost	Net changes in employment created	Contribution to GDP
		Mega t CO2 / yr	MM USD/yr	USD / t CO2	# jobs created / Mega t CO2 seq	Δ MMUSD GDP / Mega t CO2 seq
Afforestation	Baseline	4.7 (avg) 6.3 (2050)	48 (avg)	9.7	76 direct 122 indirect	62
	Sc1	7.5 (avg) 8.1 (2050)	78 (avg)	10.1	74 direct 118 indirect	65
	Sc2	13.4 (avg) 12.0 (2050)	144 (avg)	10.5	66 direct 106 indirect	67
Mangrove restoration	Baseline	Null or marginal mangrove restoration in Colombia				
	Sc1	0.4 (avg) 0.8 (2050)	5 (avg)	11.1	65 direct	69
	Sc2	1.4 (avg) 2.9 (2050)	15 (avg)	10.9	69 direct	68
BECCS	Baseline	No CCS adoption in baseline scenario, only bioenergy				
	Sc1	0.1 (avg) 0.4 (2050)	12 (avg)	72.9	271 permanent 104 construction	453
	Sc2	2.1 (avg) 4.7 (2050)	146 (avg)	69.2	259 permanent 101 construction	429
Biochar	Baseline	No biochar deployment in baseline scenario				
	Sc1	0.3 (avg) 0.4 (2050)	7 (avg)	25.0	100 industrial	161
	Sc2	3.1 (avg) 4.8 (2050)	58 (avg)	18.0	72 industrial	116

Source: Own elaboration

- Over 1,100 MW of BECCS installed capacity are forecasted for Colombia by 2050 in a high adoption scenario, potentially sequestering nearly 5 Megatons of CO2e/yr. BECCS is constrained by sustainable bioenergy potential and availability of safe storage for CO2. Similar to Argentina, in Colombia there is also uncertainty about the feasibility of timely upscaling of BECCS. CCS is largely absent from the Colombian NDC and lowly ranked in investment priorities. BECCS competes with other land based CDR approaches and mitigation measures for resources.
- Larger investments requirements like capital intensive BECCS deployment and Biochar production plants generate larger effects in employment creation and GDP contribution. Although significantly lower than in Argentina, BECCS present the highest CDR abatement cost in Colombia at an estimate of about 70 USD/ ton CO2e.

Contribution to the achievement of the SDGs

The review of knowledge, planning and implementation gaps and impact estimates were undertaken with the ultimate aim of assessing the CDR approaches against the SDGs.

The body of research on the effectiveness and potential implications of some of the CDR approaches is a new and, in many cases, exploratory field. The broader implications of CDR technologies for delivering sustainable development are insufficiently understood, particularly in LAC countries. Nevertheless, an initial effort was done to elucidate the impact of CDR approaches on the SDGs in selected countries in LAC. The potential implications identified for the SDGs are likely to differ strongly depending on the assumed scale of intervention, as well as the main hypothesis considered in terms of scenarios and contexts of its deployment.

It is important to note that while this report endeavors to present a balanced, impartial and evidence-based view of potential implications, significant gaps in knowledge mean that even if comprehensive research for each technology is undertaken, in some cases those implications may not be gauged with optimal accuracy.

The technologies assessed in LAC are untested at scale and substantially more expensive than ongoing efforts to reduce CO2 emissions. However, positive effects for non-climate related SDG delivery beyond climate action are also likely. Achieving beneficial outcomes and avoiding social and environmental harm requires more research and policy-specific impact assessments that take local conditions into account.

Implementation of large-scale CDR approaches assessed in this study would be expected to have physical side-effects and socio-economic or political implications eventually affecting the delivery of SDGs. Physical side-effects in particular relate to: land-use alternative uses and food security; water quality and availability; health; energy; economic productivity; infrastructure needs; and biodiversity. Socio-economic or political implications include: economic and cultural impacts; opportunity costs; significant financial requirements; political consistency among sectors. According to the assessment performed throughout the study, it is expected that in LAC countries large scale deployment of CDR approaches would affect the delivery of SDGs in the following manner:

Figure 6: *Potential Impacts on SDGs in LAC countries**

	SDG 1	SDG 2	SDG 3	SDG 4	SDG 5	SDG 6	SDG 7	SDG 8	SDG 9	SDG 10	SDG 11	SDG 12	SDG 13	SDG 14	SDG 15	SDG 16	SDG 17
Afforestation																	
Direct positive								8	9				13				
Indirect positive	1		3	4	5		7	8				12			15		
Direct negative						6											
Indirect negative		2	3												15		
BECCS																	
Direct positive							7	8	9				13				
Indirect positive			3	4				8			11						
Direct negative																	
Indirect negative	1	2	3			6							13		15		
Enhancing soil																	
Direct positive		2						8	9			12	13				
Indirect positive	1		3	4		6	7	8							15		
Direct negative																	
Indirect negative													13				

Source: Own elaboration

** This analysis on potential impacts of CDR deployment on SDGs is applicable for LAC countries in general and does not distinguish on any particular country*

The above assessment of impact of large-scale deployment of CDR technologies in LAC towards the achievement of SDGs is based on the positive and negative impacts, constraints and risks of each CDR technology. Therefore, an assessment of the compatibility of CDR technologies with the SDGs is as much necessary as it is still to be carried out in the region. Afforestation and Reforestation deployment in LAC countries mainly due to proven and known technology / practices:

Figure 7: *Afforestation and reforestation - Potential Constraints, impacts and risks of CDR approaches in LAC countries*

Constrains	Positive Impacts	Negative Impacts
• Land competition with other purposes • crop planted area for food production • Water and nutrients requirements • Lack of financing for long-term investments • Development of the value chain downstream: wood manufacturing and pulp and paper industry (CAPEX intensive activities)	• Women are key to ensuring forests/forestry sustainability • Potential direct and indirect jobs in wood manufacturing and pulp and paper industry • Potential development of wood related industries: construction and furniture • Affordable and clean energy based on forestry residues • Reduction of poverty levels (job creation, economic development, health, energy)	• Impacts on food supply and land tenure • Biodiversity (depending on the species to be planted) • NOX emissions from nitrogen fertilizers • Changes in evapotranspiration, albedo and cloud cover • Water scarcity

Source: Own elaboration; Vivid Economics, 2020

BECCS deployment in LAC countries allows clean energy supply, but however there is still poor knowledge of CCS phase:

Figure 8: *BECCS - Potential Constraints, impacts and risks of CDR approaches in LAC countries*

Constraints	Positive Impacts	Negative Impacts
• Land availability/ competition • Biomass feedstock availability • CO2 storage availability (technical feasibility) and CO2 storage infrastructure investment (economic feasibility) • CO2 transportation infrastructure • Poor knowledge and development of CCS phase (and therefore related technological challenges)	• Clean energy supply that increases power autonomy and security in the energy supply • Direct and permanent jobs generated (operation). • Jobs created (plants construction) and indirect jobs • Health improvement related to clean energy and forestry requirements • Know how and technical capabilities • Development of related industries	• Supply chain and LUC emissions • Water scarcity • Soil depletion • Pollution due to fertilizer use • Risk of CO2 leaks during transportation and/or storage • Impacts on food supply and land tenure • Lost C sequestration of harvested forest (wood biomass) • Impact on country's power generation cost curve

Source: Own elaboration; Vivid Economics, 2020

Biochar deployment in LAC countries increases yields but are technological challenges for its development:

Figure 9: *Enhancing soil with biochar deployment - Potential Constraints, impacts and risks of CDR approaches in LAC countries*

Constraints	Positive Impacts	Negative Impacts
• Availability of biomass for biochar production • competition with other uses • Logistic constrains: Trade-off distance from raw material (biomass) vs distance to plantations where to be applied • Technological challenges for the development, construction and operation of biochar plants • Lack of long-term financing alternatives for biochar plant (capital intensive)	• Enhanced soil properties and increasing yields (food supply) • Technological know how (dev, construction and operation) • Long-term C sequestration • Lower N2O and CH4 emissions • Higher soil water balance's • Potential on other crops • Biochar pyrolysis for power generation • Other valuable co-products: wood flavoring and adhesives • Direct and permanent jobs (construction, application)	• Logistics costs and environmental impacts of raw material and biochar transportation • Lower albedo and radiative forcing

Source: Own elaboration; Vivid Economics, 2020

B. Recommendations

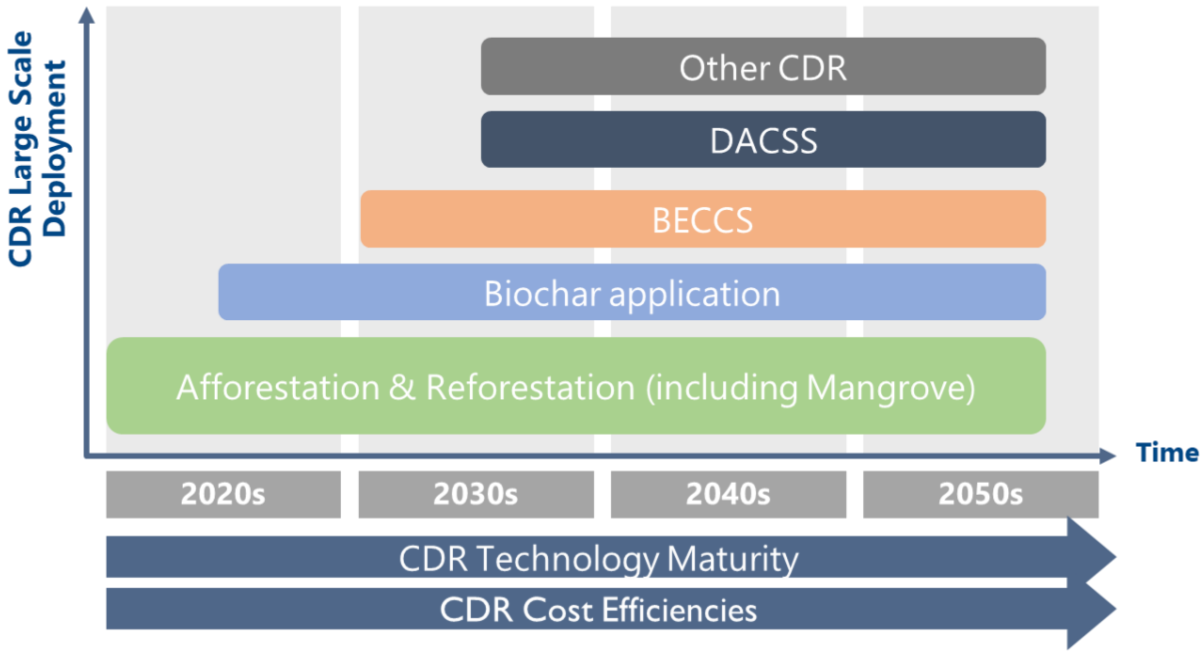
The following recommendations aim to enable better informed decision-making on the potential deployment of applicable large-scale CDR approaches in LAC.

- **Given the complexities and remaining uncertainties** associated with some of the CDR approaches analyzed, **progress is required at least in:**
  - elaboration of integrated assessment models at the national and sectoral level
  - cost-benefit analysis
  - risk analysis
  - intensification of ongoing scientific and technical research
  - multiple pilot projects
- LAC countries might face a persistent finance gap (accentuated by the pandemics). The decision on the potential CDR development would **require accurate abatement costs information and careful consideration and assessment of implementation risks.**
- Overall assessment of the **technical and economic feasibility of the CDR approaches** should be embedded in the framework to be provided by **long-term strategies elaborated by LAC countries, including next generation of NDCs.**
- **Collaborative platforms and programmes of work and a common requirement for additional international climate finance** to address the need for additional resources.
- The potential for **coalescing robust finance flows in the context of Article 6** might contribute to finance the required long-term transitions in LAC countries.
- **More transdisciplinary and geographically diverse research is required** on the linkages of large scale CDR deployment and the delivery of the Sustainable Development Goals, which may include development of common assessment principles or metrics.
- **Integrated policy impact assessments are needed** to understand potential policy designs to mobilize CDR and what implications they would have for delivery of the SDGs.
- **Afforestation and reforestation present the largest potential of carbon dioxide removal and the current lowest abatement cost in selected LAC countries and therefore should be prioritized in large-scale CDR deployment in the near and mid-term.**
- **Mangrove restoration also present a large carbon sequestration potential that could be achieved in the near and mid-term** in several countries: Brazil, Colombia, Venezuela, Ecuador, Surinam, Guyana, French Guiana and Peru.
- **Argentina and Colombia** are countries with intensive use of land for agriculture and relevant activities in this area; **further assessment might allow to improve knowledge on how CDR options reinforce synergies with existing efforts to mitigate climate change and enhance sustainable agricultural practices.**
- Eventhough a nascent field of research in LAC countries, **enhancing soils carbon content and technologies that include the use of biochar as a soil enhancer, as well as enhanced**

weathering, could be worth analyzing deeper in a site and activity-specific manner in order to quantify its potential impacts and risks at the field level.

- There is a good basis of research and initiatives/projects on the bioenergy side of the BECCS equation, however there is no integral research on BECCS, per se. Incipient but rapidly increasing installed capacity of biomass and biogas power generation plants and biofuels production plants is being observed. Nonetheless, the focus is primarily on BE.
- **Biofuels applied to power generation in non-grid connected areas (distributed generation) could have a potential for BECCS development in LAC countries**, although relevant knowledge, stakeholder commitment and implementation efforts -identified at this point in time- are scarce.
- **Efforts on large-scale CDR deployment options in the short, medium and long terms should be prioritized according to maturity and costs efficiencies.**
- **Research and demonstration pilots (e.g. DACCS, BECCS and other CDR approaches) should start well before the suggested large-scale deployment phase in order to achieve technology development and cost reduction. In the near term, large-scale demonstration of such CDR approaches will require targeted government support.**
- Latin American and Caribbean governments could **play an active role in the shaping, and guiding of the research, development and deployment of DACCS, BECCS and other CDR approaches, nationally, regionally and internationally**.

Figure 10: *Suggested Phasing of CDR Large-Scale Deployment in LAC countries*



Source: Own elaboration

Appendix: Recommended areas for further research

We suggest further research for particularly uncertain consequences of the implementation of the six CDR approaches (assessed in the research, planning and implementation gap section) in Latin America and Caribbean countries:

- **Afforestation and restoration**
  - Updated forest inventory by province/department and by species, as applicable
  - Analysis of potential impact on biodiversity arising from increased afforestation and restoration deployment
  - Analysis of potential impact on land use change arising from increased afforestation and restoration deployment
  - Analysis of water requirements arising from increased afforestation and restoration deployment
  - Long-term Wood Industrialization development plan for potential value-added realization from increased afforestation and restoration deployment
  - Innovation and Technology Transfer strategies and policies in biorefineries and nanotechnology topics
  - Promotion of wood construction and its impact on the traditional construction sector
  - International insertion of SMEs related to the wood and furniture value chain
  - Further analysis on bioenergy technologies for power generation from municipal solid waste (MSW), industrial and agriculture effluents, such as poultry and cattle residues
  - Gender equality in forestry chain employment
  - Schemes for long-term financing of afforestation/restoration projects
  - Quantification of effectiveness of incentives and tax-exemptions for its development

- **BECCS**
  - Analysis and prioritization of potential locations for new BECCS plants
  - Screening and analysis of relevant technologies and processes for BECCS plants
  - Determination of optimal scale of BECCS plants
  - Further analysis on externalities of bioenergy projects with dry biomass and biogas
  - Analysis of potential impact on land use change arising from large-scale BECCS deployment
  - Analysis of potential impact on biodiversity arising from large-scale BECCS deployment
  - Analysis of long-term impact in electricity prices resulting from changes in power generation matrix in scenarios of large-scale BECCS deployment
  - Plans and schemes for jobs retention from outplacement of thermal and coal plants
  - Risk assessment study and risk mitigation plan for large-scale BECCS deployment (particular focus on captured CO2 transportation and storage phases)
  - Analysis of materials and technologies preventing CO2 leaks
  - Schemes for long-term financing of BECCS projects
  - Quantification of effectiveness of incentives and tax-exemptions for its development
  - Innovative strategies for oriented bidding rounds for BECCS projects awarding

- **Biochar**
  - Analysis and prioritization of potential locations for biochar plants
  - Screening and Analysis of relevant technologies and process for biochar production
  - Determination of optimal scale of biochar plants and analysis on its modularization
  - Analysis and prioritization of potential areas for biochar application per crop and region (including both intensive and extensive crops)

- Determination of optimal dose and composition of biochar pellets for each crop type and each region where to be applied
- Analysis of logistics requirements and logistics costs of biochar deployment
- Analysis of potential power generation from biochar plants (from exothermic pyrolysis process) and industrial micro grids
- Procedures for safety production and handling of biochar
- Procedures for correct biochar application on soil
- Analysis of impact on employment and local communities related to biochar application on plantations
- Analysis of impact on crops yields from biochar application by main crops and regions
- Analysis of impact on soil nutrients, PH and other relevant soil properties from biochar application by main crops and regions
- Analysis of other potential uses of biochar beyond agriculture (e.g remediation of effluents, remediation of contaminated soils etc)
- Schemes for long-term financing of biochar projects
- Quantification of effectiveness of incentives and tax-exemptions for its development

Enhanced weathering land

- Analysis and prioritization of potential areas for enhanced weathering (land) application per crop and region (including both intensive and extensive crops)
- Analysis of availability of silicate minerals for enhanced weathering deployment
- Analysis of processes and technologies for mining, grinding and spreading rocks on a large-scale
- Determination of optimal dose, composition and size of grains of powder of silicate minerals for each crop type and each region where to be applied
- Analysis of logistics requirements and logistics costs of silicate minerals for deployment
- Procedures for correct silicate minerals application on soil
- Analysis of impact on employment and local communities related to enhanced weathering on plantations
- Analysis of impact on crops yields from enhanced weathering by main crops and regions
- Analysis of impact on soil nutrients, PH and other relevant soil properties from enhanced weathering by main crops and regions
- Analysis of impact on fertilizers offset
- Schemes for long-term financing of enhanced weathering projects
- Quantification of effectiveness of incentives and tax-exemptions for its development

DACCS

- Screening, analysis and prioritization of processes and technologies for DACCS facilities
- Determination of optimal scale of DACCS plants and feasibility of its modularization
- Techno-economic feasibility analysis of DACCS plants adapted to local country conditions
- Analysis of requirements, availability and supply chain of key materials (like sorbents) for large-scale DACCS deployment
- Technical research on optimal sorbent composition and properties
- Analysis of requirements and availability of energy (power) for large-scale DACCS deployment
- Analysis and prioritization of potential locations for DACCS plants
- Risk assessment study and risk mitigation plan for large-scale DACCS deployment (particular focus on captured CO_2 transportation and storage phases)
- Analysis of materials and technologies preventing CO_2 leaks
- Schemes for long-term financing of DACCS projects
- Quantification of effectiveness of incentives and tax-exemptions for its development

Ocean fertilization

- Analysis and prioritization of potential areas for Ocean fertilization
- Technical research on optimal silicate mineral composition and properties
- Assessment of impacts from increased mining industry value chain activity
- Determination of optimal silicate mineral dose per km2
- Analysis of logistics requirements and logistics costs for Ocean fertilization
- Analysis and selection of optimal techniques for ocean fertilization
- Quantification of carbon sequestration adapted to local conditions / selected ocean areas from large-scale Ocean fertilization deployment
- Impact assessment on marine ecosystem and risk mitigation plan (e.g. possible biogeochemical side effects; seafloor ecosystems effects)
- Monitoring schemes of any large-scale fertilization activity
- Schemes for long-term financing of Ocean fertilization projects
- Quantification of effectiveness of incentives and tax-exemptions for its development

Ocean alkalinization

- Schemes for long-term financing of Ocean alkalinization projects
- Analysis and prioritization of potential areas for Ocean alkalinization
- Technical research on optimal alkaline substances composition and properties
- Assessment of impacts from increased mining industry value chain activity
- Determination of optimal alkaline substances dose per km2
- Analysis of logistics requirements and logistics costs for Ocean alkalinization
- Analysis and selection of optimal techniques for adding alkalinity to the ocean (e.g. spreading finely ground alkaline substances over the open ocean, depositing alkaline sand or gravel on beaches or coastal seabeds, and reacting seawater with alkaline minerals inside specialized fuel cells before releasing it back into the ocean; others)
- Quantification of carbon sequestration adapted to local conditions / selected ocean areas from large-scale Ocean alkalinization deployment
- Explore feasibility of Co-production of hydrogen
- Monitoring schemes of any large-scale alkalinization activity
- Impact assessment on marine ecosystem and risk mitigation plan (e.g. possible biogeochemical side effects; seafloor ecosystems effects; surface pH; heavy metals)
- Schemes for long-term financing of Ocean alkalinization projects
- Quantification of effectiveness of incentives and tax-exemptions for its development