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Latin American Trade in the Age of Climate Change:

Impact, Opportunities, and Policy Options

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Foreword

Welcome to the second report from the Canning House Research Forum at the LSE.

The Forum was set up as a collaboration between Canning House and the LSE Latin America and Caribbean Centre (LACC) as a multi-year rolling programme of research and policy engagement around the overarching theme of "The Future of Trade in Latin America and the Caribbean". Hosted by the LSE LACC the programme consists of a series of individual, policy-focused research projects that aim to advance academic knowledge and offer insights of practical application to political, economic, social and business policy-making.

In 2021, the Forum produced its first report, '*Inequality and Trade Diversification: How Can Income Inequality in Latin America be reduced beyond Commodity Booms?*'. Written by Dr Amir Lebdioui, the first Canning House Research Fellow, it was launched on January 19th through an online panel discussion with Professor Vanessa Rubio Márquez (LSE), Dr Marcela Meléndez (Chief Economist for Latin America and the Caribbean at UNDP) and Mr Antonio Celia (LSE). Copies of the report, in English, Portuguese and Spanish, and recording of the event in English, with interpretation in Portuguese and Spanish can be downloaded here - www.lse.ac.uk/lacc/events/inequality-and-trade-diversification.

The second report tackles the vital topic of trade in the age of climate change. As the report makes clear, governments in Latin America and the Caribbean face enormous challenges from the threat of climate change and attempts to mitigate its impacts. As an original contribution to understanding climate change, the report considers the possible effects on trade with and within the region. The report addresses how the current trade specialisation of countries in the region affect their resilience to the effects of climate change. It considers what trade opportunities might arise from the global decarbonisation agenda and what factors might enable countries in the region to seize these opportunities. Will the anticipated gains from the boom of minerals needed to produce low carbon technologies offset the loss of revenues and jobs arising from lower demand for fossil fuels in the long term? Can the region's unique biodiversity be leveraged as a trade tool, and how? And what forms of government, private sector and international development organisation support will be needed to transform the region's trade structure towards low carbon industries and services?

The report reflects the missions of both Canning House and the LSE Latin America and Caribbean Centre to develop policy and practice-relevant research, promote discussion and understanding on and with Latin America for the benefit of governments, business and civil society. We hope that insights from this report will be of value to government ministers and parliamentarians, policymakers and regulators, opinion-formers and other research institutions and think-tanks - whether in the UK or wherever there is interest or potential interest in the region – and of course in Latin America and the Caribbean itself.

Cristina Cortes
CEO
Canning House

Professor Gareth A. Jones
Director
LSE LACC

For further information about the work of Canning House and the LSE Latin America and Caribbean Centre, see www.canninghouse.org and www.lse.ac.uk/lacc/about-us.

About the Author

Dr Amir Lebdioui leads the Canning House Research Forum, a multi-year rolling programme of research and policy engagement, consisting of project outputs as well as events on the future of trade in Latin America and the Caribbean, at the LSE Latin American and Caribbean Centre

Amir's research focuses on the political economy of resource-based development, export diversification strategies, and industrial policy in the context of climate change. Amir also regularly provides analysis and advisory for governments, multilateral development organizations, and think tanks.

He has recently joined SOAS, University of London, as a lecturer in the political economy of development. He was previously a Fellow at the LSE and an affiliated lecturer at the University of Cambridge. He holds a PhD in Development Studies from the University of Cambridge.

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Executive Summary

The economic future of Latin America and the Caribbean is intrinsically linked to climate change. In the context of a 21st century that will be marked by climate change and the global fight against it, the status quo is unlikely to help Latin American economies leap forward economically, which calls for a major rethinking of trade and investment strategies in the region. A Latin American Green Deal, based on regional coordination to exploit existing synergies and economies of scale, could be the way forward.

Across the region there is growing evidence of climate change - precipitation patterns are shifting, temperatures are rising, and some areas are experiencing changes in the frequency and severity of weather extremes such as floods and droughts. By 2050, it is estimated that climate change damage could cost USD 100 billion annually to the region. The impact of climate change, which will be more devastating in Latin America than in most parts of the world, also influences the region's ability to trade and its long-term export prospects. The increasing frequency of extreme meteorological events has already led to devastating effects on production, tourism, and trade infrastructure, while expected fluctuations in precipitation and temperature also threaten the long-term productivity of several agricultural outputs, which many countries in the region depend on as a source of exports.

Meanwhile, the global push toward decarbonisation and climate change mitigation has important implications for the region's trade prospects and bring about both challenges and opportunities for trade and investment in Latin America. On the one hand, several oil producers in Latin America are facing the uncertainty of the global energy transition, as the demand for fossil fuels is expected to drop in the medium to long term. On the other hand, several Latin American countries are poised to benefit from the opportunities presented by the transition given their large endowment of minerals that are essential to the production of low carbon technologies. Additionally, against the backdrop of a growing popularity of Green New Deal proposals in the United States and the European Union, as environmental regulations, trade standards, and consumer preferences shifts towards the consumption of more sustainable products in key consumer markets, Latin American firms face increasing pressure to adopt more sustainable production methods. To anticipate "green" trade regulations and standards, Latin American countries will have to shift their productive capabilities towards the export of green goods and services that will enjoy long-term access to the largest consumer markets. Given the highly important, complex, and multi-layered implications of climate change for Latin American trade, this report focuses on how the region can cope with the long-term effects of climate change as well as exploit the potential trade opportunities that arise from the global decarbonisation agenda.

Looking ahead, compensating for the expected job losses in the fossil fuel sector and the vulnerability of the agriculture sector imply that more needs to be done to capture the considerable job and trade opportunities that arise from the transition towards low carbon activities. Such an objective is achievable, and even necessary, but requires a significant shift in policy, investment, and vision. Fortunately, across the region, several countries are showing increasingly high environmental ambitions, pioneering biodiversity-based development initiatives, launching green economy plans,

and signing regional agreements that promise major implications for the shift to more sustainable trade.

This report puts forward five key findings and recommendations to further support the transition to sustainable and inclusive economies in Latin America and the Caribbean:

1. ***Renewable energy deployment has been a great success in Latin America, which features one of the most dynamic renewable energy markets in the world, with renewables that are already the lowest-cost source of new power generation and renewable energy capacity per capita that is twice the world average. However, more remains to be done to link renewable energy expansion with trade and industrial development.*** First, although considerable benefits (such as very high savings costs) should arise from an unrestricted cross-border trade of electricity in Latin America, such trade operations have remained limited. Second, it appears that Latin American countries, with some notable exceptions (such as the biofuels and wind energy sectors in Brazil), are mostly inserted in low value-added segments of renewable energy value chains, such as production of primary commodities, and supply, installation, and maintenance activities. Third, Latin American countries can take advantage of cheap and clean electricity sources to decarbonise electricity generation, but also as feedstock to develop competitive high value-added low carbon services and industrial activities, such as green hydrogen production, low carbon data centres and cloud services, and low carbon mining.
2. ***Latin America's endemic biodiversity and unique natural ecosystems are valuable assets and can act as a transformative force in the sustainable development of the region through biodiversity-based trade and innovation services.*** The interplay between the region's biodiversity and economic activity has taken a major place in the policy agenda in many countries. However, traditional conservation approaches have often missed opportunities to provide benefits in the form of ecosystem services to the people living in the region. Better coordinated policy efforts are needed to leverage the trade value of biodiversity. For instance, beyond domestic decarbonisation goals, carbon emissions trading systems need to cut across country and continental boundaries for carbon markets to be leveraged as trade tools. Furthermore, while ecotourism has become a popular strategy to align conservation with the growth of tradable services, an overreliance on such activity poses significant risks, especially given the vulnerability of nature-based tourism to climate change. Bio-innovation provides another promising pathway for capitalising on the trade value of biodiversity. The biodiversity of the region has inspired several interesting inventions and holds great promise in terms of future innovations. Though the biodiversity-based innovation sector has been in nascent stages in most countries, in some (such as Costa Rica) we may witness useful efforts towards bio-innovation (mainly through bioprospecting), which constitutes a very promising and emerging area for future investments, start-ups, and venture capital.
3. ***A wide range of coordinated policy tools are needed at the national level to foster the development of capabilities needed for low carbon transformations across the region.*** As illustrated with the Figure below, these include far-sighted green industrial policies such as appropriate local content incentives, business incubation initiatives, supplier-development

programmes, R&D support, and promotion of low carbon industrial clusters; skills development policies to train the workforce required for decarbonised industries and reskill energy sector workers; labour market policies to address potential labour market misalignments, especially if job losses precede job gains at a larger scale or if new jobs are emerging in regions other than those that lose jobs; financing policy to attract private investments and venture capital to nurture start-up ecosystems around low carbon services; as well as circular economy policies to help countries and communities manage scarce resources, and trade waste material to reduce the lifecycle of emissions in various industries.

Coordinated policy tools for effective green economic transformation

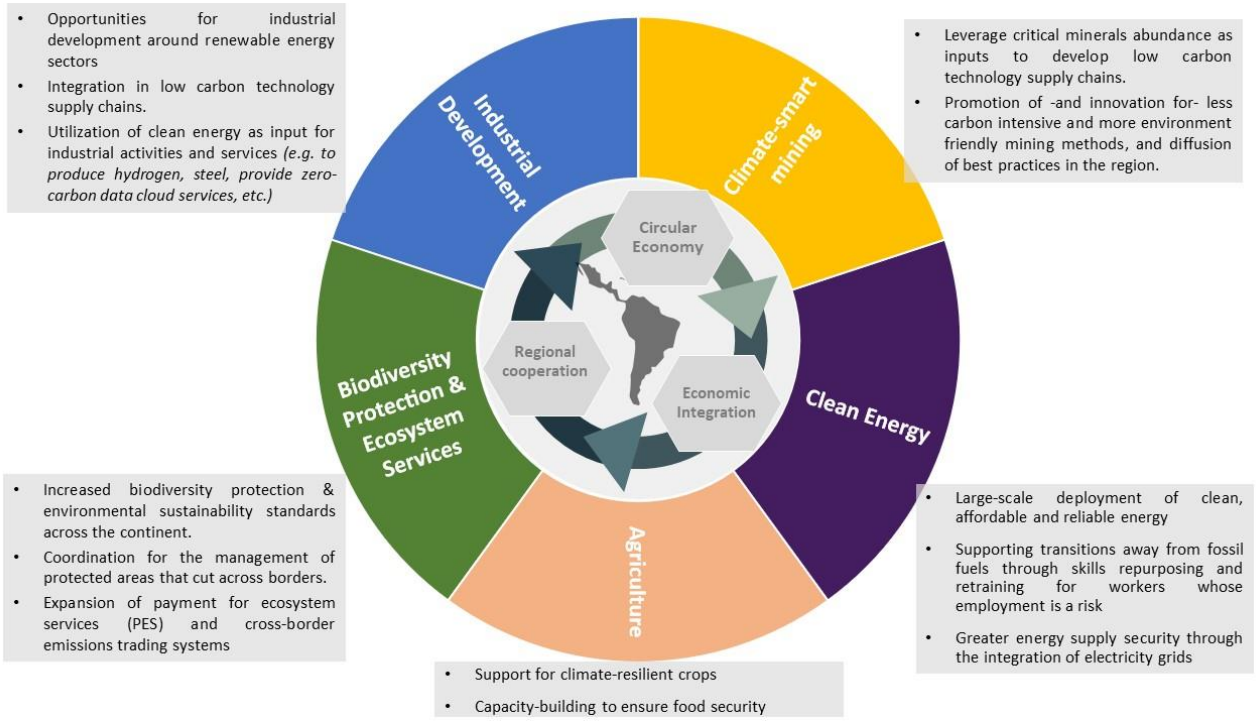
Author's elaboration

4. ***Moving forward, the extent to which Latin American countries will improve long-term prospects and benefit from the global decarbonisation agenda hinges on adequate regional coordination and the regionalisation of supply chains.*** Cooperation to promote regional supply chains around low carbon technologies, from critical mineral extraction to the production and utilization of renewable energies and low carbon services, would generate considerable productivity gains through economies of scale for local suppliers and downstream processing activities, as well as offer opportunities for diversification, job creation, and industrial development. Nevertheless, developing and strengthening regional supply chains will require appropriate policy tools and regional cooperation mechanisms. For instance, information sharing about procurement needs from mining to clean energy technology deployment will be key to addressing coordination failures in matching suppliers throughout the supply chain. In the context of very low R&D rates across Latin America, regional cooperation also provides opportunities to pool R&D resources to co-develop solutions designed for shared environments (such as high-altitude mining). The creation and

implementation of regionally and internationally recognised certification schemes will also be vital to ensure that low carbon goods (hydrogen) can be traded across borders.

5. ***Towards a Latin American Green Deal? The multifaceted nature of the policies required to promote climate-resilient development models in Latin America as well as the need for regional coordination to exploit existing synergies and economies of scale make the idea of a Green Deal particularly relevant in the Latin American context.*** A carefully designed Latin American Green Deal holds the potential to generate considerable positive impacts across a wide array of economic sectors, such as the energy sector, with the large-scale regional deployment of clean, affordable, and reliable energy sources, but also the agriculture sector and its climate resilience; the development of decarbonised energy-intensive industrial activities and technology services; inter and intra-regional trade in electricity and carbon emissions trading systems; the mining sector through support for environment-friendly extraction and value addition of critical minerals; as well as the bioeconomy through support for biodiversity conservation and ecosystem services (see Figure below). However, regional coordination is needed to foster synergies between countries and subregions, expand economies of scale, and promote the development of resilient regional supply chains for low carbon technologies. Each country has different comparative strengths, from a variety of (complementary) critical minerals that are spread across the region (e.g. Chile, Cuba, Peru, Suriname) to manufacturing capacity (e.g. Brazil, Costa Rica) and renewable energy potential (e.g. Mexico, Paraguay) as well as proximity to important trade routes (e.g. Panama), which can be strengthened in order to develop an efficient regional industrial ecosystem around low carbon technologies, if appropriate resources and policy tools are used and coordinated. Nevertheless, notwithstanding potential benefits, several obstacles remain to achieve the political coordination required at the regional level for such a programme.

Multi-sectoral transitions for green productive transformation and a Green Deal in Latin America



Source: Author's

Considering the opportunities and challenges that arise in the age of climate change, it is as clear as ever that Latin American governments, along with their international trade and investment partners, need to take bold, drastic, and necessary steps towards greener economic models based on the development of low carbon industries.

List of Acronyms

AMDEE	Mexican Wind Energy Association
ASGMI	Association of Iberoamerican Geological and Mining Surveys
BNDES	Brazilian National Development Bank
CAMMA	Mines Ministries of the Americas Conference
CINDE	Costa Rica's Investment Promotion Agency
CORFO	Chile's Production Development Corporation, CORFO
ECLAC	Economic Commission for Latin America and the Caribbean
ETS	Emissions trading system
ESG	Environmental, Social, and Governance.
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IDB	Inter-American Development Bank
IEA	International Energy Agency
ILO	International Labour Organization
INBIO	National Biodiversity Institute
IRENA	International Renewable Energy Agency
kWh	Kilowatt hour
LCOE	Levelized Cost of Energy
NDB	National Development Bank
OECD	Organisation for Economic Cooperation and Development
PES	Payments for Environmental Services Program
PV	Photovoltaics
RCP	Representative Concentration Pathway (RCP)
WDI	World Development Indicators
USD	United States Dollar

Glossary

Bioeconomy	Production, utilization and conservation of biological resources and related knowledge to provide information and services that sustain human livelihoods while ensuring ecological sustainability.
Biomimicry	Innovation method which relies on the inspiration, learning from, and imitation of the strategies found in nature to solve human design challenges.
Carbon Emissions Trading	Market-based instruments in which the government sets an emissions cap in one or more sectors, and the affected entities are allowed to trade emissions permits, which creates incentives to reduce emissions where these are cost-effective.
Critical Minerals	Minerals that are considered essential for the national and global economy, but with no viable substitutes and for which supply may be at risk of disruption (due to geological scarcity, geopolitical issues, or other factors).
Hydrogen (Grey, Blue and Green)	Grey hydrogen is the most common form and is generated from natural gas, or methane, through a process called "steam reforming." Blue hydrogen refers to hydrogen also produced from natural gas, but for which the carbon generated from steam reforming is captured and stored underground through industrial carbon capture and storage, thereby making it carbon neutral. Green hydrogen -also referred to as zero carbon hydrogen- is produced by using clean energy to split water into hydrogen and oxygen atoms through a process called electrolysis.
Levelized cost of Energy	Measure of the average net cost of electricity generation for a power plant over its lifetime, which is used to guide investment decisions.
Payments for Environmental Services Program (PES)	Financial mechanism whereby landowners receive direct payments for the ecological services when they adopt environmentally friendly land uses and forest management techniques.

Introduction

Environmental sustainability and climate change are gaining a key place in the global trade agenda. As decarbonisation commitments consolidate around the globe and Green Deal proposals appear, a salient concern in developing regions is how to build resilience to climate change but also how to adapt to the rapidly changing dynamics of consumption, production, and innovation. The implications of climate change and the decarbonisation agenda are considerable for Latin America's economies. Latin America is already starting to suffer from the devastating effects of climate change. The increasing frequency of extreme meteorological events has dramatically affected agricultural production, tourism, and infrastructure. The Inter-American Development Bank projects that by 2050, climate change damages could cost USD 100 billion annually to the region.

Against this backdrop, a series of questions must be raised. How does the current trade specialisation of the region's countries affect their resilience to the effects of climate change? What trade opportunities might arise from the global decarbonisation agenda for the region's economies, and what factors might enable them to seize these opportunities? Will the anticipated gains from the boom of minerals needed to produce low carbon technologies offset the loss of revenues and jobs arising from lower demand for fossil fuels in the long term? Who is poised to benefit, and who will lose? Can the region's unique biodiversity be leveraged as a trade tool, and how? Can market forces suffice to stimulate the region's trade structure transformation towards low carbon industries and services?

Answering such questions is vital to the future prosperity and stability of the region but is no easy task given the complex implications of climate change for Latin American trade. This report reviews how the region can cope with the long-term effects of climate change and exploit the potential trade opportunities that arise from the global decarbonisation agenda.

Latin America’s current trade profile makes it particularly vulnerable to the effects of climate change -as well as its decarbonisation - in the medium and long term.[1] Expected fluctuations in precipitation and temperature also threaten the long-term productivity of several agricultural outputs (i.e. Crops and livestock), that countries in the region depend on as a source of revenue. Meanwhile, in the context of the decarbonisation agenda, several Latin American countries are dependent on fossil fuels that are at risk of becoming stranded assets as the demand from major developed countries is expected to drop. In addition to the region’s direct productive vulnerability to climate change, Latin American firms will have to adapt as consumer demand shifts towards more sustainable products in key markets. The growing popularity of Green New Deal proposals in the United States and the European Union will inevitably bring regulatory changes that will reshape consumption patterns. The rising importance of environmental regulations in trade and their implications for Latin American economies are well reflected by the regional governments' pressure to adopt certain

[1] This stands in contrast with complex economies where the knowledge embedded in the productive structures provides linkages for the production of cleaner production technologies. See Romero, J. P., & Gramkow, C. (2021). Economic complexity and greenhouse gas emissions. *World Development*, *139*, 105317.

environmental regulations and ratify international conventions such as the Paris Agreement ahead of the EU-MERCOSUR free trade agreement.[2]

Looking ahead, with appropriate policy tools, considerable opportunities exist in Latin America to diversify towards low carbon services and industries and ensure the resilience of national economies to the effects of climate change and its mitigation, which makes compensating for the anticipated loss of revenues and jobs that will arise in carbon-intensive sectors in the region well within reach. These 'Green Windows of Opportunity' will assist Latin American countries to benefit from the global decarbonisation agenda.[3] To anticipate "green" trade regulations and sustainability standards, Latin American countries will have to shift their productive capabilities towards exporting green goods and services that will enjoy long-term access to the largest consumer markets. Several Latin American countries are also well endowed in the so-called 'minerals of the future' that are essential inputs for producing low carbon technologies and are poised to benefit from the global energy transition. However, policy reforms will be needed at the national and regional levels to avoid reproducing past commodity dependencies and benefit from the higher value opportunities that arise from green transitions.

Across the region, governments are showing increasing high climate ambitions, pioneering biodiversity-based development initiatives, and recently signed regional agreements, such as the Escazu Agreement, that will have key implications for sustainable trade. However, disparities remain in terms of starting points and national objectives in terms of sustainable trade across the region. While countries such as Costa Rica and Chile have shown great ambition towards developing globally competitive green economies, many of the region's governments have adopted policy reforms in recent years, including in response to the recent COVID-19 crisis, that have seemed to go in a different direction, opting to support carbon-intensive sectors and activities that will increase environmental degradation.

This report is divided into four main sections. The next section reviews the impact of climate change and its mitigation for Latin America's trade in the short, medium, and long term, and across a variety of tradable sectors, such as agriculture, tourism, fossil fuels, and mining. The following section provides a landscape for renewable energy in the region, in terms of renewable energy deployment, investments, jobs, trade, insertion in value chains, and value addition prospects. It shows that renewable energy deployment has been of great success in Latin America, with renewables already the lowest-cost source of new power generation. However, opportunities to leverage renewable energy expansion for trade and industrial development in the region have not been fully exploited. Though considerable benefits would arise from unrestricted cross-border trade of electricity in Latin America, such trade operations have remained limited, and the region also remains a net electricity importer. In addition, most Latin American countries, with some notable exceptions, are inserted in mostly low value-added segments of renewable energy value chains. Therefore, this section also discusses opportunities and obstacles for Latin American countries to use cheap and clean electricity

[2] Bronckers, M., & Gruni, G. (2021). Retooling the Sustainability Standards in EU Free Trade Agreements. *Journal of International Economic Law*, *24*(1), 25-51.

[3] Lema, R., Fu, X., & Rabellotti, R. (2020). Green windows of opportunity: Latecomer development in the age of transformation toward sustainability. *Industrial and Corporate Change*, *29*(5), 1193-1209.

sources as feedstock to develop competitive high value-added low carbon services and industrial activities.

The next section addresses the trade opportunities that arise from protecting some of Latin America's most valuable assets: its natural ecosystems and rich biodiversity. The interplay between the region's biodiversity and economic activity will determine the future of sustainable development. The increasing focus on sustainability at the global level prompts a discussion between the continued reliance on traditional extractive economic activity and the desire to preserve the region's unique natural treasure. Hence, this section explores the role of biodiversity-based trade services as providing a sustainable economic alternative to deforestation and environmentally damaging extractive activities in the region.

The final section turns toward the policy implications of this report. A wide range of coordinated policy tools is needed both at the national and regional levels to foster the development of competitive low carbon services and high value added ecosystem services. These include skills development programmes, labour market policies, green industrial policies, financing, and circular economy policies. Regional cooperation measures will also be key to fostering synergies between countries, expanding economies of scale, and promoting the development of resilient regional supply chains around low carbon technologies. This section ends by assessing whether a Latin American Green Deal could provide a way forward for the much-needed regional coordination around low carbon transitions.

Latin America's trade vulnerability to Climate Change and its mitigation

Overview

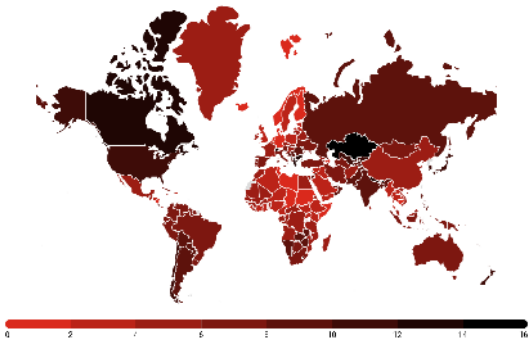
Latin America's climate is changing, with devastating effects on human livelihoods, infrastructure, natural ecosystems, and trade. Latin America is in fact, one of the most vulnerable regions to the effects of climate change. It is estimated that by 2050, climate change damages could cost USD 100 billion annually to the region.[4] The increasing frequency of extreme meteorological events has led to dramatic effects on production, tourism, and infrastructure, while long-term fluctuations in precipitations and temperature also threaten the long-term productivity of several agricultural outputs that countries depend on as a source of revenue.

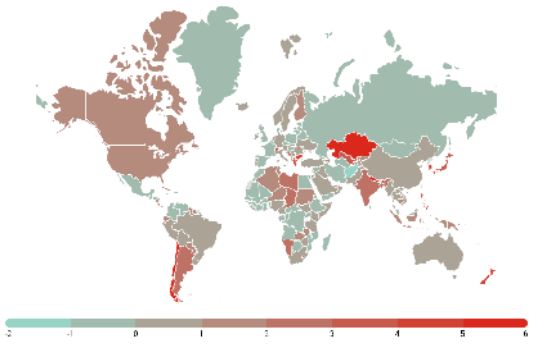
Even if we fulfil the Paris Agreement, Latin American countries are still expected to experience GDP loss, which calls for a deeper transformation of regional productive structures (see Figures 1a and 1b). Latin American trade is affected by climatic conditions and by the anticipated changes in commodity demand based on the global decarbonisation agenda. Several Latin American countries are dependent on fossil fuels that are at risk of becoming stranded assets as the demand for fossil fuels is expected to drop (see Figure 2). However, a few Latin American countries, which are well endowed in the so-called 'minerals of the future' (such as lithium, copper, nickel, bauxite) that are essential inputs for producing low carbon technologies, are poised to benefit from the global energy transition. Latin America's current trade specialisation is therefore intrinsically linked to climate change.

Figure 1a: Percent Loss in GDP per capita by 2100 in the Absence of Climate Change Policies (RCP 8.5 Scenario)

Figure 1b: Percent Loss in GDP per capita by 2100 Abiding by the Paris Agreement (RCP 2.6 Scenario)

Source: Kahn et al. 2019[5]

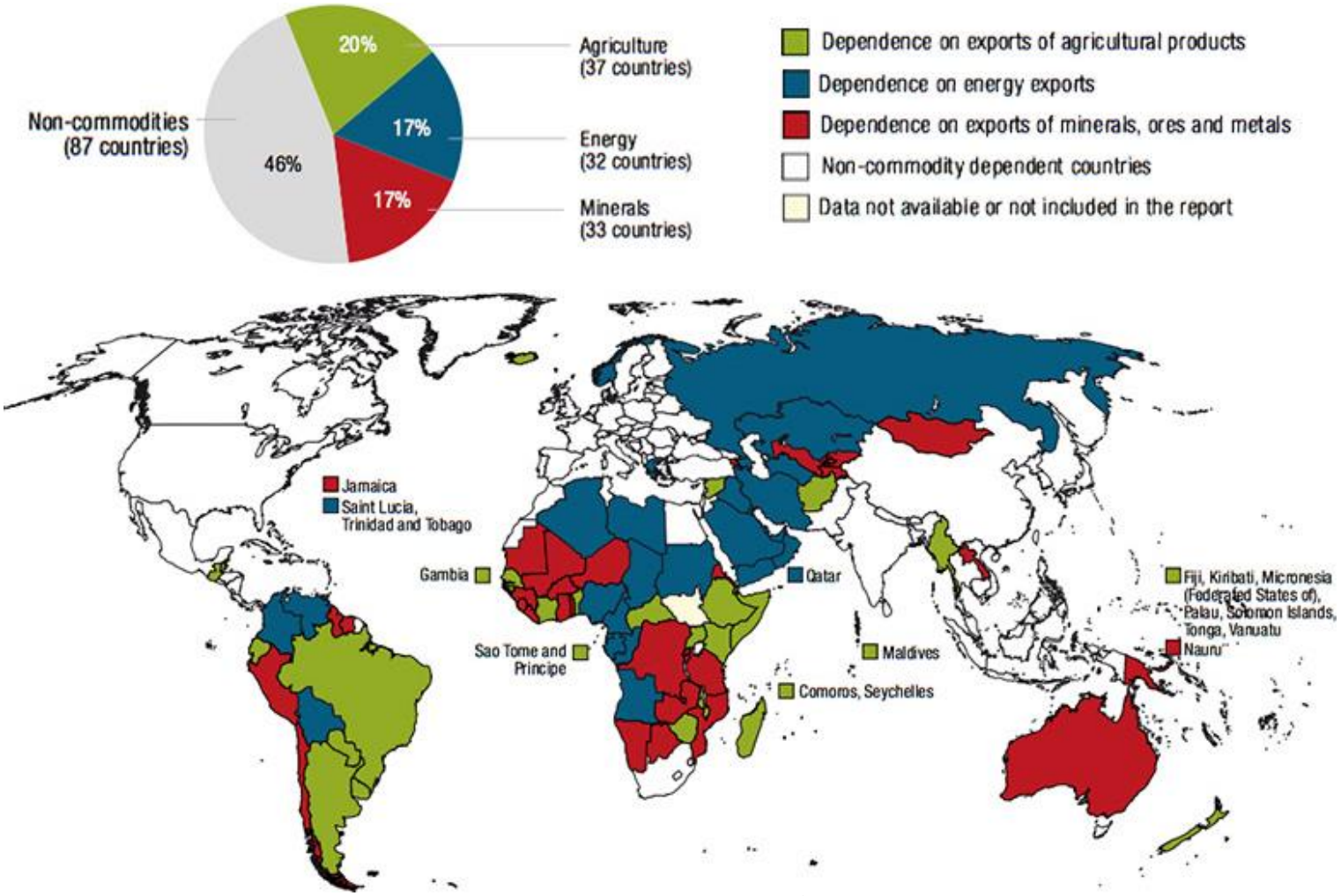




[4] Vergara, W., Rios, A. R., Paliza, L. M. G., Gutman, P., Isbell, P., Suding, P. H., & Samaniego, J. (2013). *The climate and development challenge for Latin America and the Caribbean: options for climate-resilient, low-carbon development*. Inter-American Development Bank.

[5] Kahn, M. E., Mohaddes, K., Ng, R. N., Pesaran, M. H., Raissi, M., & Yang, J. C. (2019). *Long-term macroeconomic effects of climate change: A cross-country analysis* (No. w26167). National Bureau of Economic Research.

Figure 2. Mapping commodity-dependent economies, 2013-7



Source: UNCTAD (2019)[6]

Impact of climate change and more frequent extreme meteorological events on tradable sectors

Across Latin America and the Caribbean, precipitation patterns are shifting, temperatures are rising, and some areas are experiencing changes in the frequency and severity of weather extremes such as floods and droughts. The year 2020 was one of the warmest years on record and annual precipitation totals were below the long-term average in many parts of Latin America and the Caribbean.[7] Meanwhile, the region's glaciers – which are important freshwater sources for consumption, power generation, agriculture, and ecosystem conservation- have been losing mass.[8] Sea level in the Caribbean has also been rising at a slightly higher rate (3.6mm/year) than the global average of 3.3mm/year between 1993 and 2020.[9] The region has become one of the most affected by extreme meteorological events, as reflected in 2020 with the devastation caused by Hurricane

[6] UNCTAD (2019) *State of Commodity Dependence.* Geneva: United Nations.
[7] World Meteorological Organization (2021). *State of the Climate in Latin America and the Caribbean 2020.* WMO: Geneva.
[8] Ibid.
[9] Ibid.

Eta and Iota across Central America, as well as the intense drought and fires in the Pantanal region of Brazil, Bolivia, Paraguay, and Argentina.[10]

In addition to the tragic loss of human lives they cause, such events have an impact on tradable sectors, especially agriculture and tourism. Nature-based tourism activities, which represent a key source of revenues and employment in Latin America (accounting for as much as 40% of export earnings in countries such as the Dominican Republic)[11], are likely to be most affected by climate change. For example, the 2017 hurricane season resulted in an estimated loss of more than 800,000 visitors to the Caribbean, which would have generated USD740 million and supported about 11,000 jobs.[12]

A banana plantation is destroyed after being submerged in water during a big flood due to heavy rains in Eldorado city, Ribeira valley, south of São Paulo state, Brazil. / Nelson Antoine (Shutterstock)

[10] World Meteorological Organization, op. cit.

[11] Gouvea, R. (2004). Managing the Ecotourism Industry in Latin America: Challenges and Opportunities. Problems and Perspectives in Management, 2(2)

[12] Saget, Catherine, Vogt-Schilb, Adrien and Luu, Trang (2020). Jobs in a Net-Zero Emissions Future in Latin America and the Caribbean. Inter-American Development Bank and International Labour Organization, Washington D.C. and Geneva. Accessible at https://www.ilo.org/wcmsp5/groups/public/---americas/---ro-lima/documents/publication/wcms_752069.pdf

When it comes to agriculture, for instance, drought conditions throughout 2020 significantly impacted crop yields across the region: almost 80% of maize grown in Guatemala's highland region was lost, while in Mexico, the Cerritos municipality suffered a 50% drop in cultivated crops, including sorghum, sunflower, and corn.[13] Meanwhile, hurricanes Eta and Iota caused:

- USD2.159 billion in losses representing 0.8% GDP, and damaged over 287,315 hectares of crops, affecting around 4 million people in Honduras.
- damages to 220,000 hectares of cultivated land and losses of 43,667 livestock animals, USD172 million in losses, and estimated material damages affecting 1.8 million people in Nicaragua.
- 119,913 hectares of damaged cultivated land and the death of 126,812 animals, affecting 1.2 million people in Guatemala.

Latin American exports are threatened by climate change, given that agriculture presents over 60% of exports in at least 6 Latin American countries. Besides the high frequency of extreme meteorological events and sporadic effects on agriculture production, the long-term gradual impacts of climate change also affect agricultural trade (and food security). The region (and particularly Argentina, Brazil, Chile, Ecuador, and Uruguay) is largely dependent on agro-commodities, where productivity is particularly vulnerable to fluctuations in temperature and precipitation. Just to note a few prominent examples, climate change poses a serious risk to salmon farming in Chile, coffee in Colombia, and cacao in Ecuador.[14]

The impact of the decarbonisation agenda on Latin America's non-renewable resources

Fossil fuels

Several Latin American countries, such as Bolivia, Colombia, and Venezuela, are dependent on fossil fuels that are at risk of becoming stranded assets as the world decarbonises its economic systems. The global transition to a decarbonised economy will have profound effects on the fossil fuels sector and cause the loss of over 360,000 jobs in fossil fuel extraction and fossil fuel-based electricity generation in the region.[15] It is further estimated that as the world draws closer to net-zero emissions, most jobs in petroleum and coal power plants (93% to 94%) would disappear by 2030, while 80% of jobs in gas power plants and 70% of fossil fuel extraction jobs would disappear by 2050.[16] Policy action will be needed to maximise job gains in other sectors and help the

[13] World Meteorological Organization, op. cit.

[14] Soto, D., León-Muñoz, J., Dresdner, J., Luengo, C., Tapia, F. J., & Garreaud, R. (2019). Salmon farming vulnerability to climate change in southern Chile: understanding the biophysical, socioeconomic and governance links. *Reviews in Aquaculture*, *11*(2), 354-374; Macías Barberán, R., Cuenca Nevárez, G., Intriago Flor, F., Caetano, C. M., Menjivar Flores, J. C., & Pacheco Gil, H. A. (2019). Vulnerability to climate change of smallholder cocoa producers in the province of Manabí, Ecuador. *Revista Facultad Nacional de Agronomía Medellín*, *72*(1), 8707-8716.

[15] Saget et al., op. cit.

[16] Ibid.

reinsertion in the labour market of workers who lost their jobs due to the decarbonisation agenda (see section 5).

Natural gas faces favourable prospects in the medium term given its potential as an 'intermediary' energy, while oil faces greater difficulties with the global energy transition. Although petroleum will not disappear completely because of its use for a wide range of non-energy products such as pharmaceuticals, cosmetics, and plastic goods, it can nonetheless be expected that the oil-producing countries with high costs of extraction will be driven out of the market. The cost of production of an oil barrel in Latin America tends to be higher than in other world regions. For instance, the total costs for producing one barrel of oil has been higher in countries such as Brazil (USD 35); Venezuela (USD 28) compared with competitors such as Iran and Saudi Arabia (USD9 both); Iraq (USD 11), Russia (USD19) or even Norway (USD 21), while the cost of production in Colombia fluctuated from USD16.3 in 2017 to USD45 in 2020.[17] Once oil prices resume their predicted trajectory after the 'Ukraine shock', it is therefore expected that Latin American countries with higher production costs will be driven out of the market first.

Mining

Other Latin American countries are poised to benefit from the increasing demand for minerals that are essential inputs of low carbon technologies needed to mitigate climate change. Considering recent trends, such as the growing importance of the sustainability agenda, the global expansion of carbon-neutrality pledges, and the broader context of the climate crisis, it is evident that critical minerals will play a key role in fuelling the global energy transition and future economic transformations. Latin America and the Caribbean is well placed to benefit from such trends because of the existing endowment in various (complementary) critical minerals spread across the region. Critical minerals are considered essential for the national and global economy, but with no viable substitutes and for which supply may be at risk of disruption (due to geological scarcity, geopolitical issues, or other factors). Their identification is highly context-dependent across space (a mineral critical to a country's economy might not be considered critical in another region) and across time: the importance of a mineral and the nature of its supply chain can change over time, due to technological innovations/disruptions. Presently, critical minerals represent a growing market because they are used in a range of strategic industries, such as renewable energies, e-mobility technologies, and consumer electronics. Several critical minerals are required as inputs in the transition to clean energy systems and in the fight against climate change. For instance, lithium, nickel, cobalt, manganese, and graphite are crucial to battery performance, longevity, and energy density.[18] An electric car contains twice as much copper and higher quantities of nickel, manganese, and graphite than a car with a combustion engine. At the same time, a 3-MW wind turbine requires as much as 335 tons of steel, 4.7 tons of copper, 3 tons of aluminium, 2 tons of rare earth elements, as well as zinc, and manganese (see Figure 3). [19] As a result, in a scenario in which the Paris

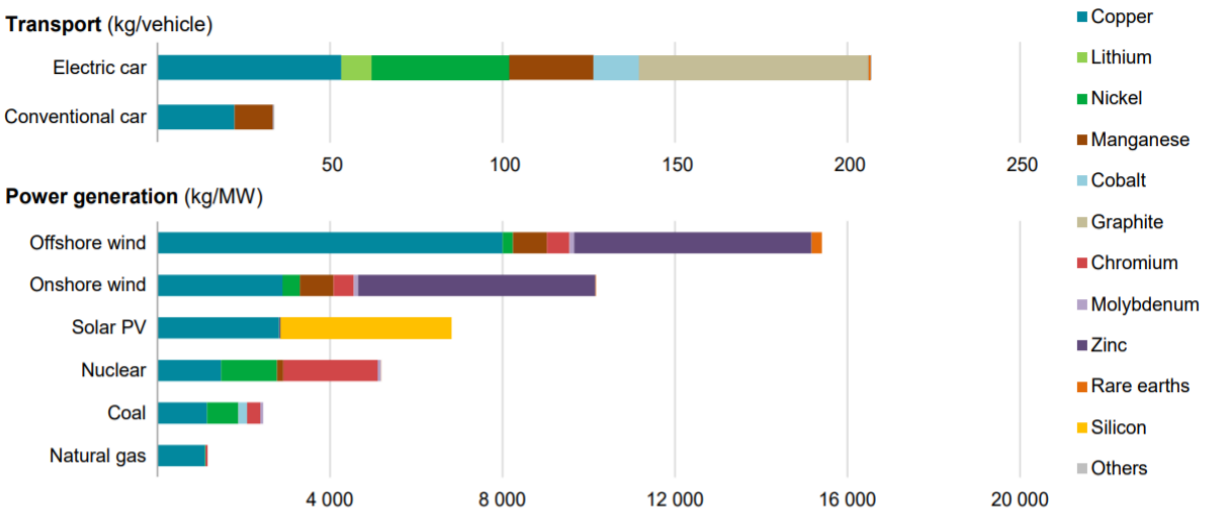
[17] ***Wall Street Journal*** **(2016) 'Barrel Breakdown', 15 April. Available at: http://graphics.wsj.com/oil-barrel-breakdown/ (accessed December 2020); Asociación Colombiana de Petróleo (ACP).** ***Costos De Operación Del Sector Petrolero En Colombia En 2017*****. Bogotá: ACP.**

[18] International Energy Agency (2021). *The Role of Critical Minerals in Clean Energy Transitions.* Paris: IEA.

[19] La Porta; D. Hund, K.L.; Mccormick,M.; Ningthoujam,J.; Drexhage,J. (2017). The *Growing Role of Minerals and Metals for a Low Carbon Future (English).* Washington, D.C.: World Bank Group.

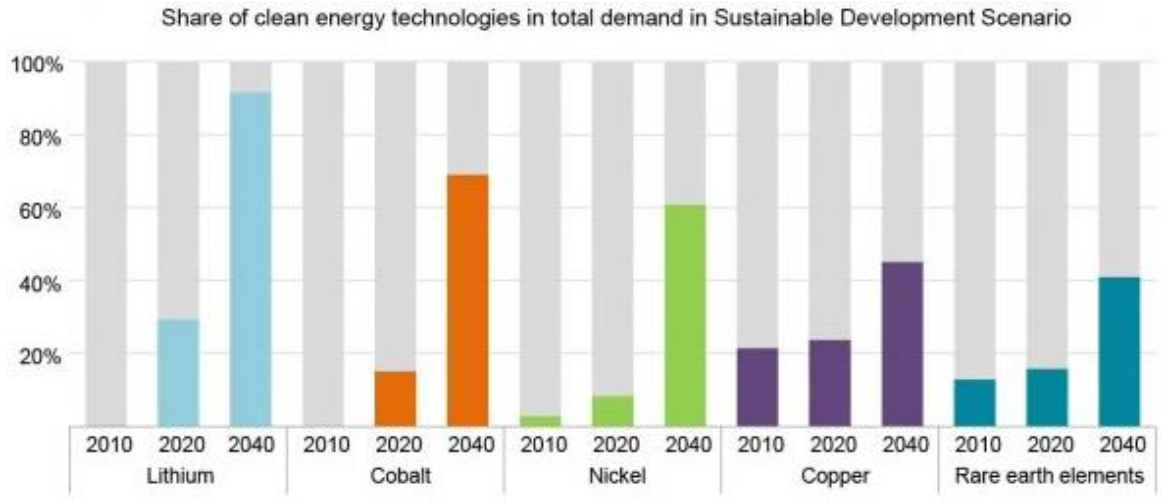
Agreement goals are met, the demand for critical minerals would rise significantly over the next two decades (see Figure 4).

Figure 3. Mineral use in key low carbon technologies



Source: IEA (2021)

Figure 4. Expected evolution of demand for key critical minerals



Source: IEA (2021)

Critical minerals will play an increasingly significant role in Latin American trade. Latin American countries present a large -and spread out- endowment in critical minerals and the existence – and potential for developing downstream industries that utilise those minerals as inputs, especially in Brazil (see Section 3). For instance, Latin America dominates the production -and holds very large reserves- of a range of critical minerals, such as lithium, copper, silver, as well as bauxite, zinc, manganese, nickel, and graphene to a lesser extent (see Figure 5). With appropriate policy tools, the region is geared to benefit from the growing market for critical minerals and low carbon technologies required to meet climate goals, especially if the industrial capacity to refine and process those minerals is further developed.

Figure 5. Latin America's share of critical minerals reserves

Source: Author's based on various sources and datasets

However, even for countries dependent on the so-called 'minerals of the future' for which demand is expected to increase with the deployment of low carbon technologies, the long-term outlook is still dominated by high levels of uncertainty and risks of technological disruption. There is historical precedent. In the early 20th century, the discovery in Germany of a new way of producing ammonia had a dramatic economic impact on Chile, which was highly dependent on the extraction of natural deposits of sodium nitrate. Such a scenario is not unthinkable today for Latin American countries such as Chile or Bolivia that are currently relying on minerals such as lithium[20], given the copious amounts of resources invested in R&D to develop alternative electric battery technologies (such as solid-state batteries, or hydrogen-based batteries, especially in China, Japan, and the USA) that rely on substitute minerals and raw materials. Decisions to invest in downstream value addition capacity or electric batteries production in lithium-producing countries must therefore consider the potential risks of technological disruptions. These can be considerable given the narrowness of the forward linkages that exist from commodities such as lithium in contrast to minerals such as copper or silver, which enjoy a wide range of applications.

In addition, challenges persist in terms of the environmental damages caused by the extraction of those minerals, such as soil contamination and water issues. In the context of a low carbon future,

[20] Perotti, R & Coviello, M. (2015). "Governance of strategic minerals in Latin America: the case of Lithium," *Documentos de Proyectos 669.* Santiago: ECLAC.

increasing pressure is expected for Latin American mining producers to adopt less carbon-intensive extraction methods. Such pressure also stems from the social conflicts that arise from the expansion of mining activities and community concerns about environmental pollution.[21] Innovations for biomining (or green mining) will therefore be essential moving forward, as already pushed in Chile through the application of bioleaching to copper mining.[22] The push for biomining in Chile since the 1990s resulted from a combination of factors, such as the rising copper prices, the depletion of higher-grade ore, increased costs associated with traditional processes, and a growing concern for the environment.[23] Taking advantage of the new opportunities opened by biotechnology, several innovations have been studied and attempted, such as the use of seawater to leach copper oxide ores in the Lince Project, a collaboration between the Finnish and Chilean mining companies Outokumpu and Minera Michilla, which was the first operation in the world to use seawater as the sole water source in a controlled leach operation. In Chile, around 10% of copper is currently obtained by bioleaching.[24] Notwithstanding its potential limitations, bioleaching (which consists of using bacteria to obtain copper from low-grade ores) presents several technological, environmental, and economic advantages as compared with pyrometallurgy.[25] The reduction of the carbon footprint of extractive industries through biomining has implications for long term productivity, and could even change the feasibility of investment projects, because of:

- The potential to reduce costs in the event of carbon taxes,
- The potential to increase the social acceptance of mining activities, thereby reducing the cost of conflict,
- The potential for higher profit margins through a premium paid for 'greener' products in the market,
- And the possibility of retaining (or gaining) market share in response to pressures for greening entire supply chains and sustainability standards imposed by leading firms or governments.

Moving forward, the extent to which Latin American countries will benefit from the critical minerals boom hinges on the adequate regionalisation of supply chains. Cooperation to promote regional supply chains around critical mineral extraction will allow considerable productivity gains through economies of scale for local suppliers and downstream processing activities in the critical minerals sector, as well as offer opportunities for diversification, job creation, and industrial

[21] Haslam, P. A., & Tanimoune, N. A. (2016). The determinants of social conflict in the Latin American mining sector: new evidence with quantitative data. *World Development*, *78*, 401-419; Mara Weiß, Stefan Giljum & Sebastian Luckeneder (2020) Mining and social conflict in Latin America: Which factors drive conflict escalation, *FINEPRINT Brief No. 11,* July.

[22] Gentina, J.C., and F. Acevedo (2013). 'Application of Bioleaching to Copper Mining in Chile'. Electronic Journal of Biotechnology, 16(3).

[23] Domic, 2007Domic, E.M. (2007). 'A Review of the Development and Current Status of Copper Bioleaching Operations in Chile: 25 Years of Successful Commercial Implementation'. In D.E. Rawlings and D.B. Johnson (eds), Biomining (pp. 81–95). Berlin/Heidelberg: Springer.

[24] Benavente J.M. and Goya, D. (2011). 'Copper mining in Chile', *Sectorial Report, Project Opening up Natural Resource-Based Industries for Innovation: Exploring New Pathways for Development in Latin America, IDRC.;* Pietrobelli C., Marin A., Olivari J. (2018), "Innovation in mining value chains: New evidence from Latin America," *Resources Policy,* 58, pp. 1-10

[25] Gentina and Acevedo, op. cit.

development. Nevertheless, developing and strengthening regional supply chains will require appropriate policy tools and regional cooperation mechanisms, which is why section 5 of this report also highlights the opportunities for using critical minerals as a lever of development in the Americas.

Aerial view of hundreds solar energy modules or panels rows along the dry lands at Atacama Desert, Chile. / Abriendomundo (Shutterstock)

Renewable Energy and Related Value Chains

Overview

Latin America has one of the most dynamic renewable energy markets in the world. More than a quarter of primary energy in the region comes from renewables, twice the global average, while renewable energy capacity per capita in the region is almost twice the world average, notably due to the steady increase of investments in renewable energy projects since 2000. Latin America and the Caribbean also boasts the least carbon-intensive electricity sector in the world, thanks to possessing the highest share of hydroelectricity in total supply.[26]

In many parts of the world but in Latin America more specifically, renewables are already the lowest-cost source of new power generation. Costs for renewable energy technologies have fallen to the extent that solar and onshore wind power no longer need financial support to compete with conventional power generation in a growing number of Latin American countries.[27] Utility companies in Mexico, Peru, and Chile are already procuring solar and wind-based electricity for as low as 3 cents per kilowatt-hour (kWh). That is the lowest cost globally for power generation from any source, and about 6 times cheaper than electricity produced from coal, oil, or gas.[28]

However, more can be done to capture the socio-economic benefits of renewable energy development, such as energy access, quality jobs, innovation and knowledge spillovers, and

[26] ILO (2018). *Presente y futuro de la protección social en América Latina y el Caribe*. Accessible at https://www.ilo.org/wcmsp5/groups/public/---americas/---ro-lima/documents/publication/wcms_633654.pdf

[27] IRENA (2020). Global Renewables Outlook: Energy transformation 2050. International Renewable Energy Agency, Abu Dhabi.

[28] Ibid.

clean energy manufacturing capacity. Despite considerable progress, the energy sector has not reached its full potential, as energy/electricity consumption remains quite low in the region. Access to electricity is an important component of modern life and Latin America and the Caribbean has witnessed remarkable progress in terms of electricity access in the last 25 years. However, Latin America and the Caribbean still had about 10 million people without access to electricity in 2019 (a significant decline from 27 million people 10 years earlier), 90% of whom live in rural areas.[29] Cross-border electricity trade also remains limited despite the potential and considerable cost-savings it entails, while more needs to be done to capture the potential quality job gains in the renewable energy industry, especially in countries and sub-regions that need to compensate for the expected job losses in the fossil fuels sector. This is because most Latin American countries, except for Brazil, are inserted in low value-added segments of renewable energy value chains, with very limited manufacturing and innovation development taking place. Considerable opportunities exist and are starting to be explored when it comes to using renewables to fuel sustainable industrial development in the region, as explained in this section.

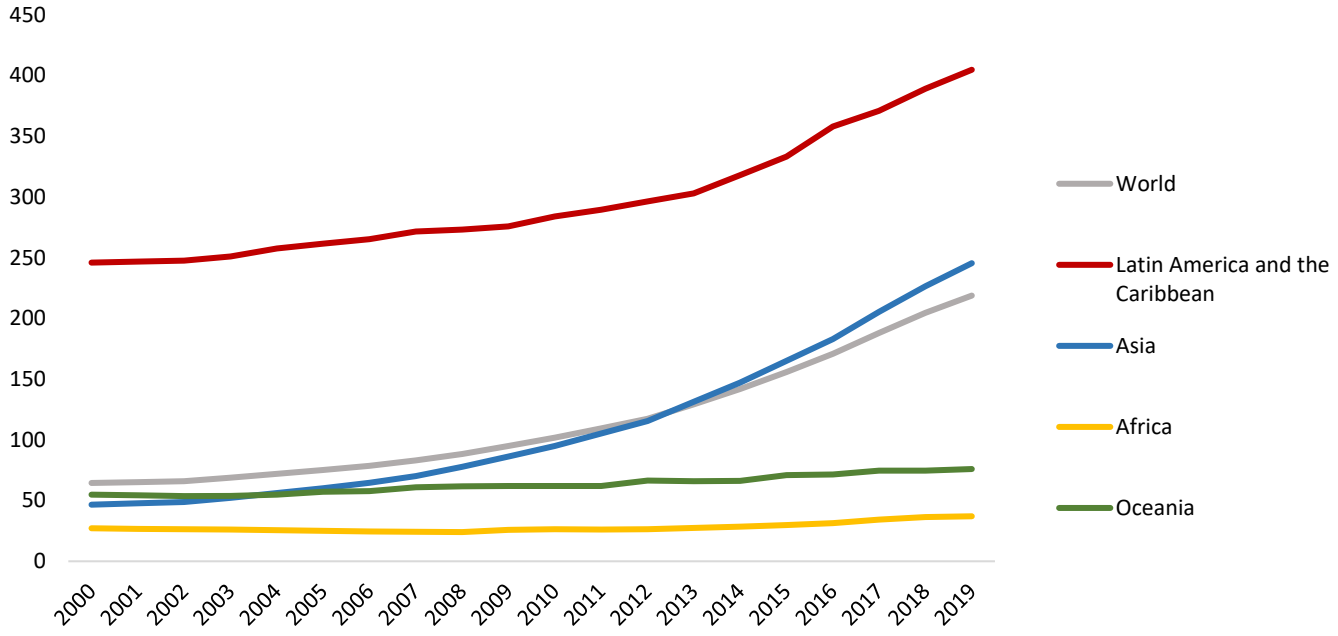
Renewable energy deployment

Renewable energy per capita in Latin America and the Caribbean is almost twice the world average (see Figure 6). In 2010, the average renewable energy capacity per capita in Latin America was about 284 kWh. By 2019, the capacity had increased by 43%, up to 405 kWh. In 2019, Paraguay, Uruguay, and Brazil had the highest figures in the region, followed by Chile (see Figure 7).

However, considerable subregional disparities exist, as renewable energy capacity per capita is quite high for South America (517 kWh per capita), far lower in Central America (214 kWh per capita), and extremely low in the Caribbean (77 kWh per capita).

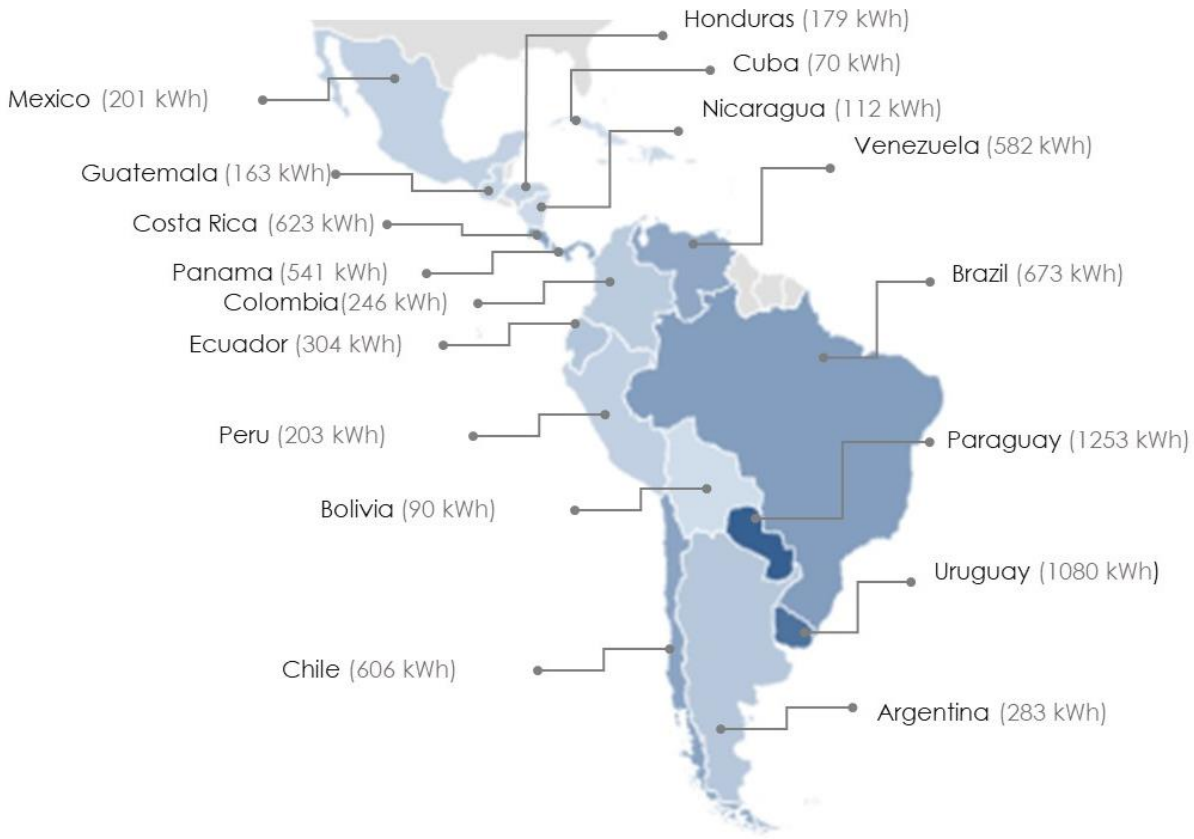
[29] World Bank (2021). World Development Indicators. Available at: https://data.worldbank.org

Figure 6: Renewable energy capacity per capita, by regions, in kWh per capita (2000-2019)



Source: Author's calculations based on IRENA data

Figure 7. Map of Renewable Energy Capacity per capita (2019)



Source: Author's elaboration based on IRENA data

Despite an impressive deployment of renewables in Latin America, energy needs are not fully met in several countries. The energy access gap is still high in some countries (especially Nicaragua, Guatemala, and Peru). In addition, on average, businesses in Latin America suffer 2.8 electrical outages in a typical month, usually lasting 1.5 hours, and nearly 40% of firms in the region have identified the power sector as a major constraint for developing its full potential.[30] Furthermore, low-income households tend to experience more blackouts and power surges than high-income households.[31] The lack of electricity service continues to be a significant obstacle to improving people's lives in many parts of the region. Although the share of the population with access to electricity was above 98% in 2019[32], the average energy and electricity consumption per capita are below the world averages of 28,884 kWh and 3,322 kWh, respectively.[33] Only four countries in the region (Paraguay, Trinidad and Tobago, Chile, and Uruguay) featured electricity consumption rates above the world average in 2020 (see Figure 8). Whether this is good or bad news – that is whether the low energy consumption in the region means that Latin Americans have a low energy intensity standard of living, or simply that too many people are energy poor- is unclear.

Beyond access to energy, the idea of energy poverty can be defined in terms of whether electricity access meets the daily needs (the exact amount varies according to local conditions, such as the average annual temperature) and the cost of electricity. A recognised benchmark identifies households as energy-poor if they need to spend more than 10% of income on fuel to maintain an adequate level of warmth (the UK's official definition of energy poverty). While the challenge is to do more with less energy, energy is needed to provide the basic goods and services that ensure the well-being of current and future generations, and region-wide primary energy demand is expected to be at least 80% higher than present-day levels by 2040.[34]

Countries in Latin America and the Caribbean can be broadly classified into four groups:

- Those that rely heavily on fossil fuels as sources of electricity generation (Trinidad and Tobago, as well as Argentina, Dominican Republic, Jamaica, and Mexico)
- Those that rely heavily on hydropower (Paraguay, Brazil, Panama, Costa Rica, and Ecuador)
- Those with a diverse mix between fossil fuels and renewables (Chile, Colombia, Guatemala, Peru, Suriname, Venezuela)
- And those with a diverse mix of renewables (Uruguay)

Each of these groups face different challenges and starting points when it comes to energy transitions. The countries that depend on fossil fuels face the greatest urgency in addressing the transition to clean energy sources, given the non-renewable nature of those resources that may run out within a few decades (see Section 2). Countries that depend on hydropower also face the need to diversify their energy mix due to the high vulnerability of hydropower to climatic conditions.[35] A

[30] World Bank Enterprise Surveys.

[31] Inter-American Development Bank (2014). *Megacities & Infrastructure in Latin America: What its people think*. Washington, D.C.: Inter-American Development Bank.

[32] World Bank (2021), op. cit.

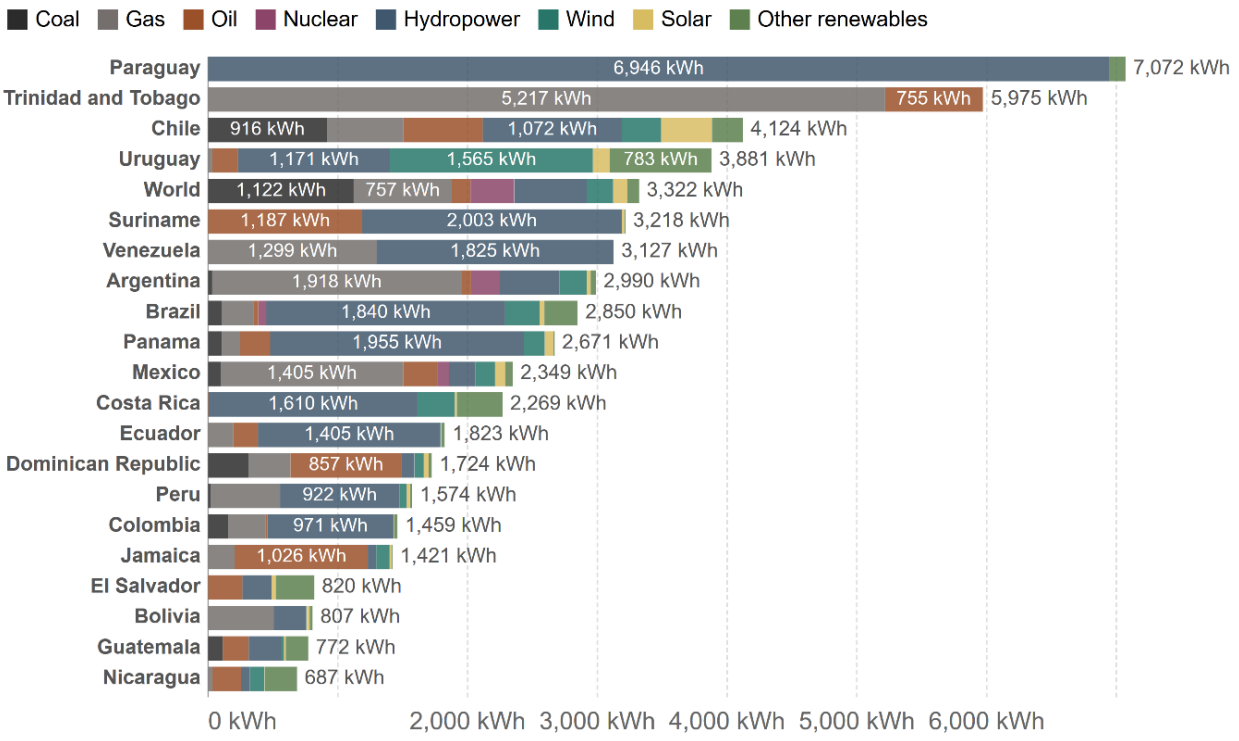
[33] BP Statistical Review of World Energy; Saget et al. op cit.

[34] Balza et al (2016). *Lights On? Energy Needs in Latin America and the Caribbean to 2040.* Washington DC: IDB

[35] IDB (2016). Vulnerability to Climate Change of Hydroelectric Production Systems in Central America and their Adaptation Options. Washington DC: IDB; IEA (2021), *Climate Impacts on Latin American Hydropower*: Paris: IEA

dry season, and/or higher temperatures, can cause significant hydropower shortages (for example, in the Rio Jubones Basin in Ecuador).[36] Countries with a diverse mix of energy sources have a more resilient energy matrix, although the challenge of expanding clean energy capacity persists in countries where energy needs are not fully met.

Figure 8: Per Capita Electricity Consumption by source, 2020



Source: Our World in Data based on BP Statistical Review of World Energy & Ember

Investment

The period 2010-2021 has seen USD3.3 trillion invested in global renewable energy capacity (excluding large hydropower projects), more than three times the amount invested in the previous decade. Latin America and the Caribbean has attracted around 7% of these global investments. Total investment in renewables in Latin America reached almost USD 200 billion between 2010 and 2021. Investments in renewable energy capacity in Latin America have also increased almost twenty-fold since 2005, to reach a record 24.3 USD billion in 2021. Investment in renewable energy sources in the region have grown faster than the world average since 2005.[37]

The distribution of investments in renewables have been quite uneven within the region. Three countries, Brazil, Chile, and Mexico have accounted for three-quarters of renewable energy investment in the region since 2010. Brazil has attracted the most investments in the region, with

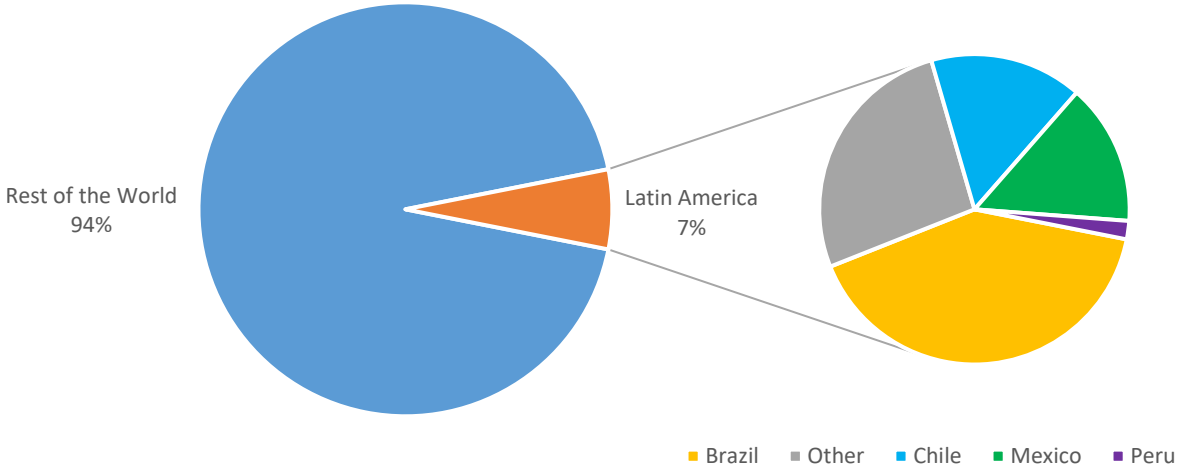
[36] Hasan, M. M., & Wyseure, G. (2018). Impact of climate change on hydropower generation in Rio Jubones Basin, Ecuador. *Water Science and Engineering*, *11*(2), 157-166.

[37] Calculations based on BloombergNEF data.

over USD 12 billion of investment in renewable energy in 2021, ranking it 9th in the world. Between 2010 and 2021, three Latin American countries (Brazil, Mexico, and Chile) made it into the top 20 countries in terms of investment in renewables, with a combined investment exceeding USD 100 billion.[38]

The technology composition of renewable energy investments in Latin America has changed considerably over the past two decades. In 2008, biofuels (and to lesser extent biomass and waste) accounted for over 60% of renewable energy investments in the region. By 2021, solar and wind energy accounted for over 99% of new investments. The growth of the solar energy market has been particularly spectacular, with investments rising from USD1.2 billion to USD15.2 billion within the past decade.[39]

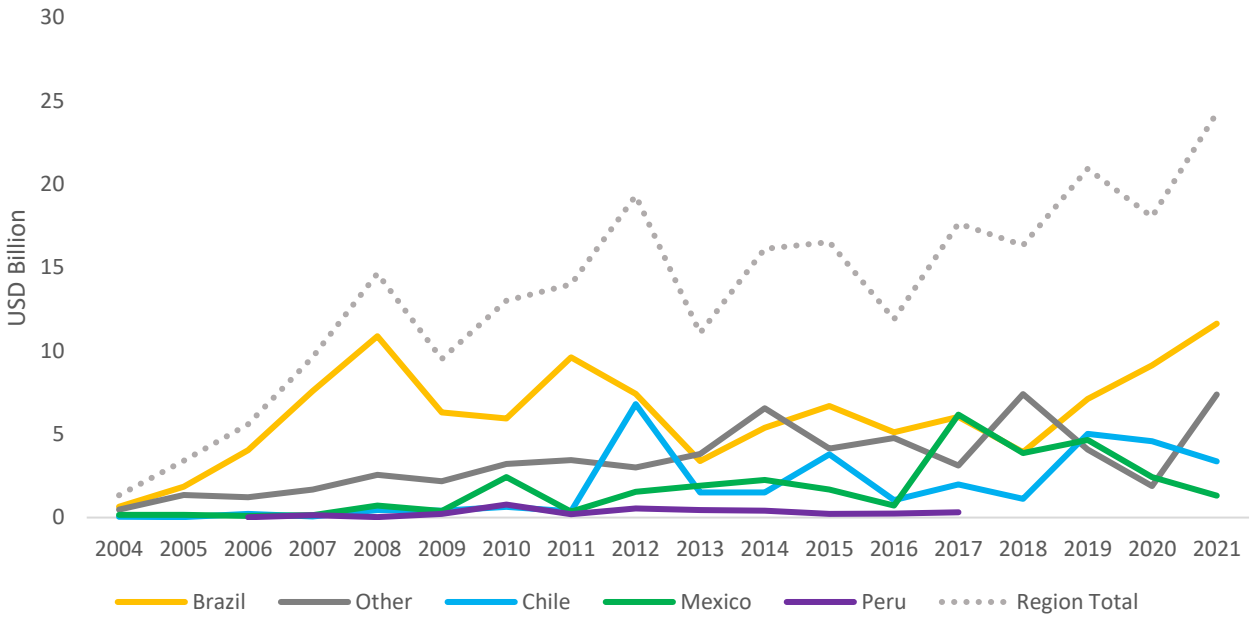
Figure 9. Investments in Renewable Energy (2010-2021)



Source: Author's calculations based on Bloomberg NEF (BNEF) data

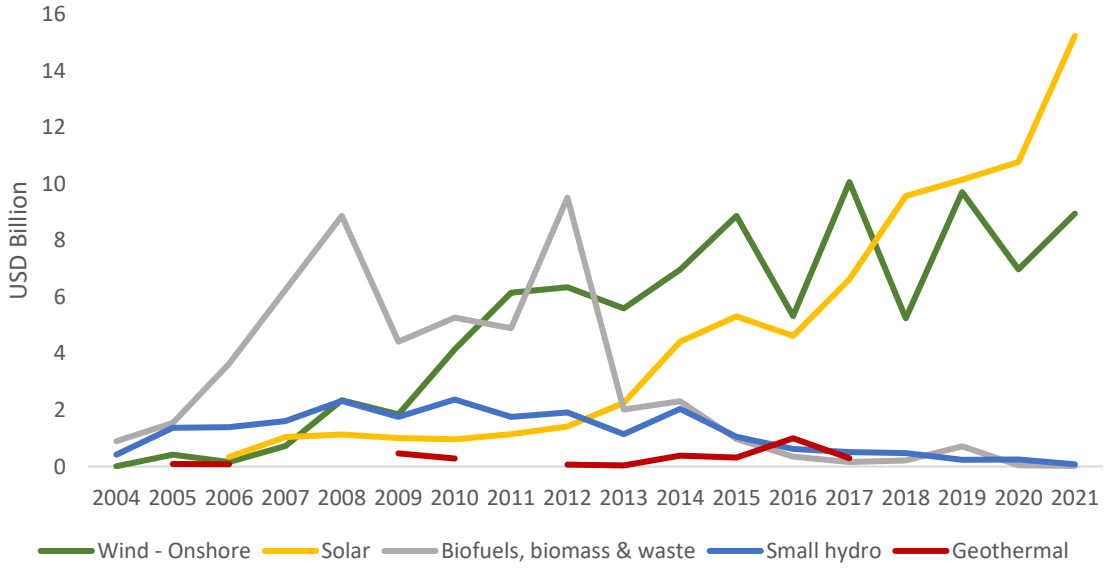
[38] Ibid.
[39] Ibid.

Figure 10. Investment in Renewable Energy in Latin America and the Caribbean, by country



Source: Author's calculations based on Bloomberg NEF (BNEF) data

Figure 11. Investment in Renewable Energy in Latin America and the Caribbean, by technology



Source: Author's calculations based on Bloomberg NEF (BNEF) data

Public financing has been the main driver of renewables expansion. At least 14 Latin American countries have already established dedicated renewable energy public funds or renewable energy-eligible funds.[40] Each fund has different sources, including government ad hoc or regular contributions, specific taxes, cross-subsidies, or donations from international development partners.[41] However, public funding for renewables in the region has also often been volatile over the past decade (see Figure 10), especially in countries (such as Ecuador) that depend on oil revenues characterised by high price volatility.[42] Moving forward, ramping up and stabilising public funding for renewables, as well as attracting private investments through renewable energy value chains, will be a key priority (see Section 5.1).

Electricity trade

Although considerable economic benefits should arise from international and cross-border electricity trade in Latin America, and despite the region's potential and competitiveness for producing low-cost and low-carbon electricity, such trade operations have remained limited, and the potential benefits have not been fulfilled.[43] The electricity trade globally is growing and reached about USD35billion in 2019, and countries in Latin America traded around USD 2.2 billion worth of electricity. Brazil accounted for around 56% of those imports, followed by Argentina (20%), Mexico (15%) and Colombia (3%). With about USD1.6 billion, Paraguay was the largest exporter of electricity in Latin America (accounting for 80% of electricity traded in Latin America and 4.4% of world electricity exports (see Figure 12). It was distantly followed by Guatemala (USD 259 million), Mexico (USD 228 million), Uruguay (USD 88 million),[44] Ecuador (USD 67 million). Electricity derived entirely from hydropower represents over 20% of Paraguay's export. Over 90% of the country's generated energy is exported to neighbouring Brazil (75%) and Argentina (25%).

[40] IRENA (2015) *RD&D for Renewable Energy Technologies: Cooperation in Latin America and the Caribbean.* Abu Dhabi: IRENA

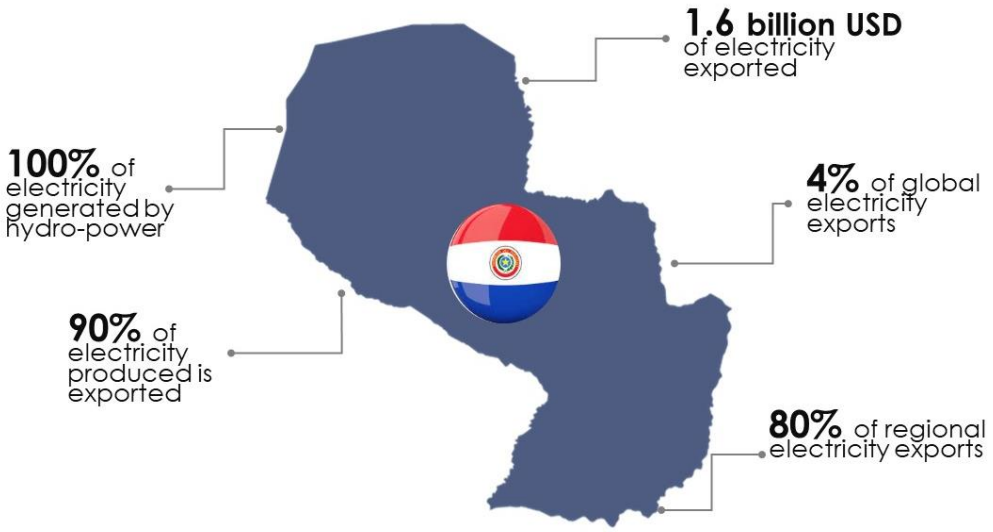
[41] Ibid.

[42] Anzolin, G., & Lebdioui, A. (2021). Three dimensions of green industrial policy in the context of climate change and sustainable development. *The European Journal of Development Research*, *33*(2), 371-405.

[43]Timilsina, G., Deluque Curiel, I., & Chattopadhyay, D. (2021). How Much Does Latin America Gain from Enhanced Cross-Border Electricity Trade in the Short Run? Washington D.C.: World Bank.

[44] Data from UN Comtrade.

Figure 12. Key renewable energy indicators in Paraguay



Source: Author's calculations various data sources

There is the potential for considerable savings on electricity supply costs if Latin American countries allowed unrestricted electricity trade across the borders without expanding their current electricity generation capacity. The benefits of regional trade in electricity are particularly high when variable energy sources can work together on a systemic basis, as in the case of Nord Pool, which is the pan-European power exchange system. Recent evidence shows that the volume of cross-border electricity trade would increase by 13% with an unconstrained subregional trade of electricity (between countries within the Andean, Central, and Mercosur subregions) and 29% under a full regional trade involving all 20 countries.[45] The region would gain USD1.5 billion annually under the subregional scenario and almost USD2 billion under the full scenario. The Andean subregion would realise more than half of this gain under both scenarios.[46] These are short-term benefits attainable even without expanding the current electricity generation capacities. In the future, as Latin American countries add more generation capacity to meet increasing demand, the benefits of trading electricity will be even higher. Therefore, fostering the integration of Latin American countries into a regional electricity grid constitutes a key policy priority moving forward (as further discussed in Section 5.2).

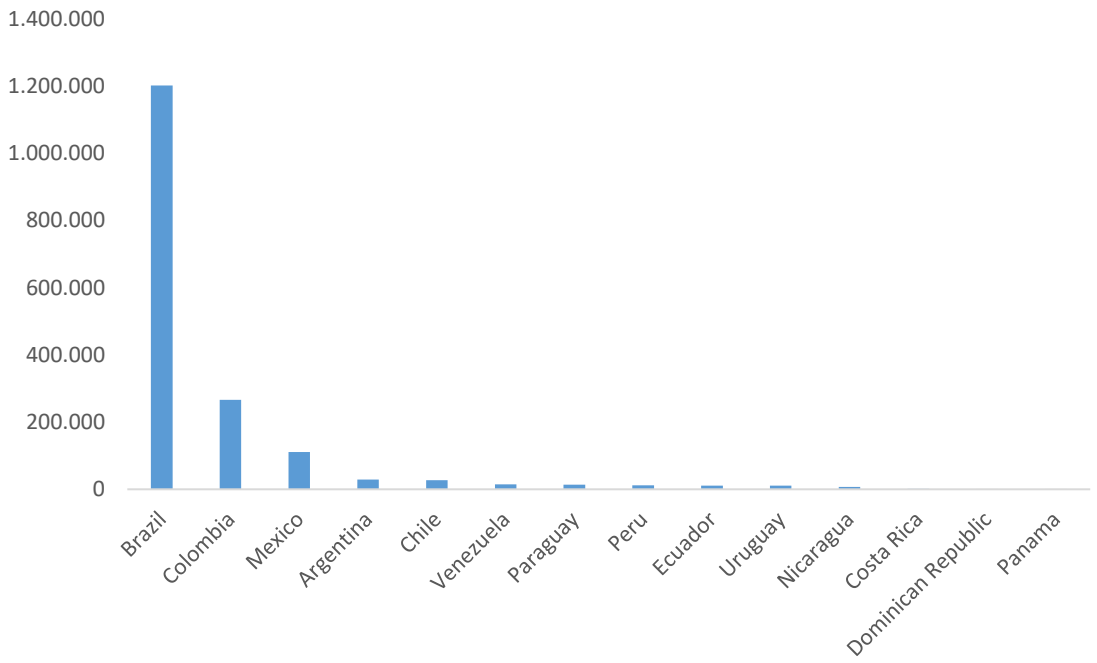
Jobs

Substantial job creation potential exists in renewable energy sectors. Deploying renewables can stimulate industrial development and generate a wide range of jobs in construction, manufacturing, and operations and maintenance. Jobs in the renewable energy sector have steadily increased over the past decades, to reach 12 million in 2020. Almost 40% of these jobs are in China, and 14%

[45] Timilsina et al., op cit.
[46] Ibid.

(around 1.7 million) were created in Latin America, the bulk of which are in Brazil with over 1.2 million jobs.[47]

Figure 13. Jobs in renewable energy sectors by Latin American country, as of 2020



Source: Author's calculation based on data provided by IRENA

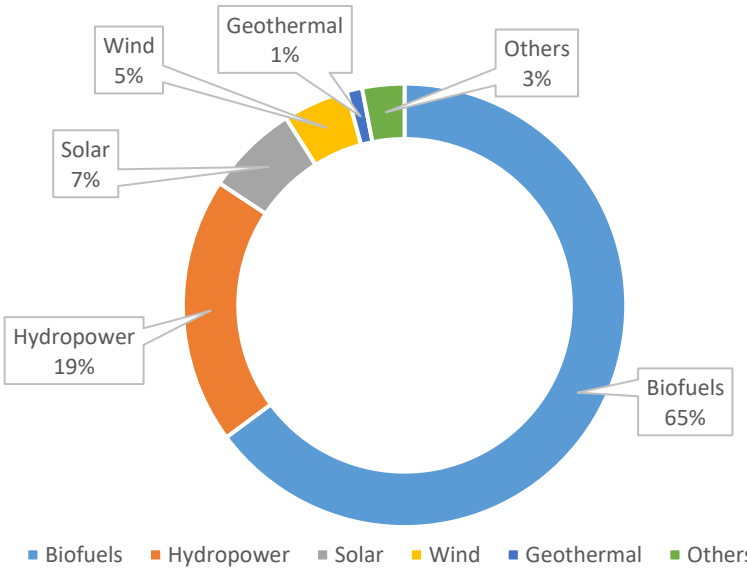
The bulk of jobs in renewable energy have been in biofuels and to a lesser extent in hydropower (see Figure 14). Latin America accounts for 44.4% of all biofuel jobs worldwide, with Brazil alone accounting for 36% of jobs in biofuels worldwide (with almost 900,000 jobs), followed by Colombia (around 200,000 jobs).[48] Hydropower is the second source of employment in the renewable energy sector, with Brazil ranked number three in the world for employment in hydropower. Meanwhile, wind power currently employs over 80,000 people in Latin America. Again, Brazil leads the way in terms of jobs in both onshore and offshore energy generation, whilst Mexico has recently increased its overall wind capacity. Brazil and Mexico respectively rank 6th and 8th in terms of employment in the wind sector. According to the Mexican Wind Energy Association (AMDEE), about 56% of the country's jobs in the wind sector were in manufacturing, 34.5% in construction, and 9.5% in operations and maintenance.[49] Elsewhere in the region, there is an estimated 9,400 jobs in the wind energy sector in Chile, and this number is expected to grow considerably given the country's recent large-scale investments to accelerate wind energy deployment.

[47] IRENA (2020). *Renewable Energy and Jobs – Annual Review 2020*. Abu Dhabi: IRENA.

[48] IRENA (2021a). *Renewable Energy and Jobs – Annual Review 2021*. Abu Dhabi: IRENA.

[49] Zarco, J. (2020), "Inversión de 11.4 mil millones de dólares en la generación de Energía Eólica, 6,160 MW instalados y más13 mil empleos en México", PV Magazine Mexico, 16 June.; Zarco, J. (2021), "Oaxaca Eólica...Oaxaca Renovable", PV Magazine Mexico, 25 August.

Figure 14. Renewable energy employment in Latin America by energy source



Source: Author's calculation based on data provided by IRENA

Looking ahead, compensating for the expected job losses in the fossil fuels sector implies that more needs to be done to capture the potential job gains in the renewable energy industry. Policies aimed at facilitating the reallocation and repurposing of workers and encouraging the localisation of activities with potential for quality job gains will therefore be essential (see Section 5 on policy implications). Under the Paris Agreement and the call to limit global temperature rise to 1.5°C, the renewable energy sector is estimated to account for 38 million jobs by 2030 and 43 million by 2050.[50] Estimates also suggest that the transition to a green economy offers the promise of creating 15 million net new jobs in Latin America and the Caribbean (especially in solar and wind power, not including sustainable agriculture and forestry).[51] These job prospects also hold enormous potential for reducing gender inequality, given that one third of jobs in renewables are held by women, which is much higher than the share of female employment in the fossil fuel sector.[52]

In addition to the *number* of jobs created, Latin American countries also need to make sure to capture some of the *quality* job gains that arise from the energy transition. Decent jobs with good wages and safe working conditions are necessary to ensure a 'just transition.' Nevertheless, to date, most of the jobs created have been in construction, operations, and maintenance, which tend to be temporary, low-paid, and low-skilled. For instance, in Brazil, 58% of the jobs in the wind sector are estimated to be in construction and 16% in operations and maintenance (compared with 13% and

[50] IRENA (2021a), op. Cit.
[51] Saget et al., op. cit.
[52] IRENA 2021ª, op. Cit.

3% in Europe, respectively), leaving 26% for manufacturing.[53] National manufacturing and local content activities have grown since 2014, but many jobs are still low-skilled and temporary.[54] In this sense, the further integration of local content and value-added activities within global renewable energy supply chains remains a challenge (as discussed in the next section).

Box 1. Renewable energy jobs in Brazil

Brazil has an estimated 1.2 million renewable energy jobs, with a majority of these in biofuels. Overall, job numbers have remained relatively unchanged in recent years, but the employment composition is shifting. Within the biofuels sector, employment in biodiesel production has climbed (324000 jobs in 2020), but employment in ethanol production has declined (547,000 jobs). This decline is expected to continue as ethanol production sector becomes increasingly mechanised.

Brazil's wind power production and employment is also rapidly increasing. IRENA estimates the country's wind workforce at about 40,000 people, primarily in construction, operations, and maintenance, which tend to be temporary, low paid, and low-skilled.

Brazil's solar sector is also growing, and it employed around 68,000 people in 2020. The bulk of solar PV panels are still imported, as domestically produced modules, which are eligible for low-interest-rate financing; met around 3.8% of demand in 2020 (Greener, 2021).

Source: IRENA (2021)

Manufacturing and renewable supply chains

Despite the growth of the renewable energy market, it appears that Latin American countries, with some notable exceptions, are mostly inserted in low value-added segments of renewable energy value chains. There are two strategies available to policymakers regarding renewable energy deployment: a fast-track approach and a slow-track approach.[55] A fast-track strategy entails the rapid adoption and deployment of low carbon technologies largely acquired through imports. This approach would promote, for example, the installation of the greatest number of turbines in the shortest possible time through the imports of wholly assembled wind turbines. A slow-track strategy goes beyond mere renewable energy adoption and deployment measures and would promote the production of equipment that feeds directly into renewable energy value chains. So, for example, developing a domestic manufacturing capability base for wind turbines. Except for Brazil, and Uruguay to a lesser extent, most Latin American countries have adopted a fast-track approach. To

[53] Simas, M., & Pacca, S. (2014). Assessing employment in renewable energy technologies: A case study for wind power in Brazil. *Renewable and Sustainable Energy Reviews*, *31*, 83-90.

[54] Hochstetler, K. (2020) *Political economies of energy transition: wind and solar power in Brazil and South Africa*. Cambridge University Press.

[55] Lema, A., & Ruby, K. (2006). Towards a policy model for climate change mitigation: China's experience with wind power development and lessons for developing countries. *Energy for Sustainable Development*, *10*(4), 5-13; Lema, R., Johnson, B., Andersen, A. D., Lundvall, B-Å., & Chaudhary, A. (2014). Low-Carbon Innovation and Development. Aalborg Universitetsforlag.

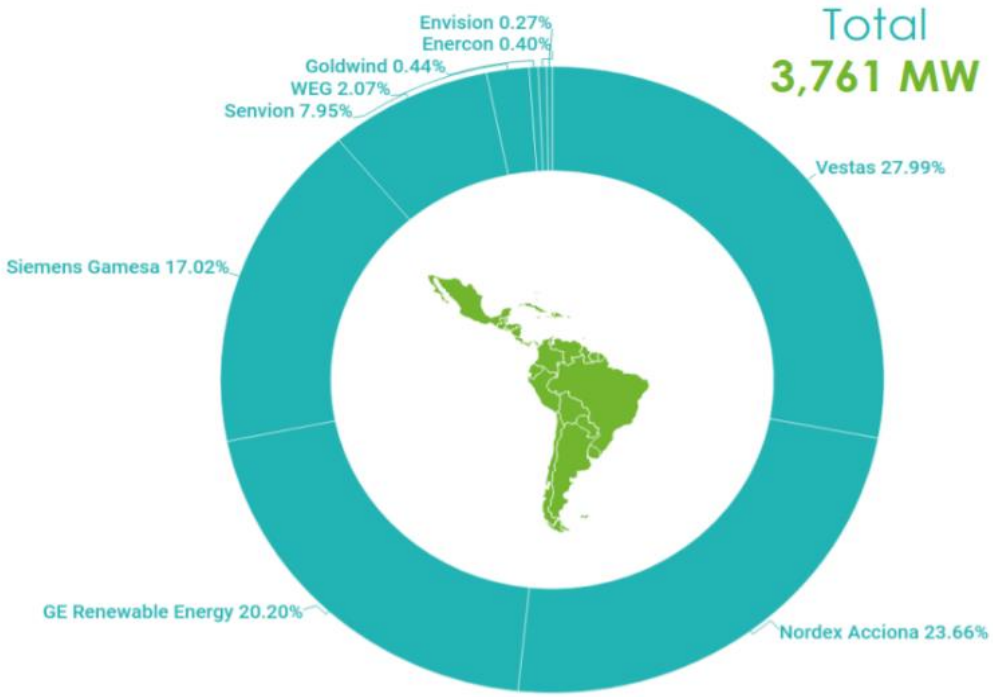
date, most of the renewable energy technology has been imported (with the notable exception of biofuels and locally produced wind turbines in Brazil). Integration to global value chains has been largely limited to the export of raw materials required to produce low carbon technologies such as copper, lithium, balsa wood, iron ore, and plastics.

Despite the existence of wind turbine manufacturing capacity in Brazil and Argentina, export capacity remains very limited, and most installed wind turbines have been imported. The wind turbine sector deserves particular attention; it offers interesting perspectives on the supply chain regionalisation in Latin America compared with other renewable energy technologies:

- First, a considerable range of raw materials is available in different parts of the region.
- Secondly, Latin America is one of the regions with the highest demand for wind turbines, and the transport of wind turbines incurs very large eco economic and environmental costs (due to the size of the turbines and the carbon intensity of international shipping activities).
- Thirdly, domestic manufacturing capacity exists, in Brazil and Argentina (albeit to a lesser extent). Lastly, the potential for disruption and competitiveness is higher where prospects for competitiveness are more limited. However, to date, most wind turbines installed in Latin America have been imported from China**.** In 2020, Chinese exports of finished nacelles (the major power generation component of wind turbines) represented 82% and 59% of imports in Chile and Mexico, Latin America's two largest importers of finished nacelles, worth a total USD 855 million across the two countries. Other 'smaller' partners included the United States, Denmark, and Spain.

At the firm level, Vestas, Nordex Acciona, GE Renewable Energy, and Siemens Gamesa all held between 17% and 28% of the Latin American market for wind turbines in 2019 (see Figure 15). Local producers of wind turbines and related components exist and have managed to enter the market, but their market share remains marginal. These include WEG (Brazil), Aeris Energy (Brazil), Wobben Windpower (Brazil), and IMPSA (Argentina). With 2.1% of the regional market, WEG, the largest Latin American supplier of wind turbines, slipped to the sixth position in 2019 as the company lost more than 5% market share in Latin America compared to the previous year. All its operations in 2019 were in its home market, Brazil.

Figure 15. Wind Turbine Market Share in Latin America by firm.



Source: GWEC Market Intelligence

Considerable hurdles remain in attracting investments in local manufacturing capacity and regional supply chains around renewables. Some of the leading foreign-owned wind energy firms have invested in local factories (mostly in Brazil), but the bulk of their operations rely on imported turbines. Vestas has invested in wind turbine production in Brazil, where the low levelised cost of energy could be achieved through local manufacturing because of tax breaks for investments in local production as well as high volumes sold in Brazil (2GW for Vestas in 2021 alone). In Mexico, the company's operations also rely on local suppliers of towers and blades. However, some of the main obstacles to investing in the expansion of local manufacturing capacity in the region are the volatility of demand and unstable energy politics (Vestas Manager for Latin America, Personal Communication). Due to frequent policy changes, operations in Mexico, Brazil, Colombia, and Argentina have experienced considerable fluctuations from year to year, making expansion difficult. Moving forward, promoting a more stable renewable energy market, through the establishment of a clear roadmap in the medium and long term, as well as clearer regulations and public communications regarding renewable energy objectives, will be essential for providing investor trust in local renewable energy-related manufacturing capabilities (see Section 5).

Notwithstanding existing challenges, local content policies have been an effective tool to localise higher value-added activities within wind turbine value chains in Brazil.[56] An instance of 'slow-

[56] Local content requirements were also introduced in 2009 in Uruguay, with an auctioning call to small wind farms of 30-50MW with a required local content of at least 20%, and a minimum requirement of 80% of employees to be locally hired.

track' development is offered in the case of Brazil, where the Brazilian National Development Bank (BNDES) has played an important role in supporting the wind turbine manufacturing industry by offering competitive financing for wind power installations (at rates well below market levels) while imposing local content requirements.[57] These local content requirements slowed the introduction of wind power capacity until after 2009, but eventually contributed to a substantial national industry as they became "the most effective guarantor of ongoing localized production of electricity components" according to Hochstetler.[58] By 2014, domestic content in Brazil's wind energy manufacturing sector was already about 89%.[59] However, the success of the sector has also relied on the ability to leverage the pre-existing domestic capabilities in aircraft manufacturing, which raises questions regarding the replicability of this success in the context of other Latin American countries, which do not have the same pre-existing manufacturing capabilities nor Brazil's large domestic market size. For instance, Uruguay and Argentina have also introduced local content requirements. In Chubut (Argentina), existing assessments suggest mixed results, and that the low financial incentives and the rigid timeline of local content requirements have been a serious hindrance to wind power development.[60]

Innovation and R&D

Innovation and R&D play an essential role in developing, adapting, and deploying renewable energy technologies.[61] On that front, Latin America's track record is mixed. On the positive side, the region has spearheaded several R&D activities around renewables, including developing short-term forecast tools for wind generation, hydrokinetic turbines for use with marine currents, and smart mini grids for electrification of isolated and rural communities, and biofuel production from microalgae.[62] Amongst those, one case worth highlighting is the R&D efforts that underpinned the successful development of biofuels in Brazil (see Box 2). The use of biofuels as a substitute for diesel was first attempted over a century ago but scaling-up was restricted due to the high viscosity of biofuels and poor performance as an energy source.[63] However, in the late 1970s, the Brazilian government launched the National Renewable Energy Alternatives from Vegetable Sources Programme which aimed at the technical development of vegetable oils for use in diesel engines. Thereafter, R&D capabilities around biofuels were supported by a range of programmes, including the Network for Research and Technological Development on Biodiesel, which includes representatives from the public, private and academic sectors, as well as the National Programme of Production and Use of Biodiesel, launched in 2005 (see Box 2). Today, Brazil's biofuels sector is widely considered a success, given that Brazil has become the second-largest producer of liquid biofuels for transport and the industry generates almost one million jobs.

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[57] Hochstetler, op. cit.

[58] ibid.

[59] IRENA (2019). *Renewable Energy and Jobs – Annual Review 2019*. Abu Dhabi: IRENA.

[60] Jacobs, D. (2012). "Feed-in tariffs: Design options and case studies for developing countries." January 26, 2012. Leonardo Webinar.

[61] Lema, R., Iizuka, M., & Walz, R. (2015). Introduction to low-carbon innovation and development: insights and future challenges for research. *Innovation and Development*, *5*(2), 173-187.

[62] IRENA (2015), op. cit.

[63]Schwab, A. W., Bagby, M. O., & Freedman, B. (1987). Preparation and properties of diesel fuels from vegetable oils. *Fuel*, *66*(10), 1372-1378.

Box 2. Brazil's R&D efforts in the biofuels sector

The first Brazilian patent on biodiesel was obtained in 1983, shortly after the launch of the National Renewable Energy Alternatives from Vegetable Sources Programme and the resulting R&D with pure esters and blends with 30% ester from soybean oil, due to the greater availability of this feedstock.[64]

Increasing concern about the sustainability of energy systems, as well as the evolution of biodiesel production in Europe, generated an increase in the interest in biofuels in Brazil, and prompted several policies aimed to stimulate R&D. In 2002, the Ministry of Science and Technology created the Network for Research and Technological Development on Biodiesel, with representatives from universities, the automotive industry and potential biodiesel producers. In 2005, the Brazilian government aimed to strengthen existing R&D capabilities by launching the National Programme of Production and Use of Biodiesel.

In 2006, Petrobras Biocombustível, a subsidiary of Petrobras, Brazil's state-owned oil company, was created to support the production of -and R&D around- biofuels. To promote technological development around biofuels, Petrobras Biocombustível led several R&D initiatives which mobilized 19 public agricultural research centres.[65] Those initiatives started with the launch of pilot plants to produce biodiesels in 2006 and included the establishment of an oilseeds research network in 2010, which provides funding and technical support to public agricultural research centres.[66]

Today, biofuels meet about 25% of demand for road transport fuel. The development of biofuels has also led to considerable socio-economic benefits, such as job creation. For instance, ethanol production generates approximately 32 times more jobs per unit of energy produced compared to the petroleum sector.[67] Despite increasing mechanisation, the industry also generated over 500,000 direct jobs, most of which are formal jobs. Indeed, while around 40% of Brazilian agricultural workers are formally employed, 81.4% of employees in sugarcane production are formally hired and have access to employment benefits.[68]

[64] Ministry of Industry and Trade of Brazil (1979). Programa Tecnológico Industrial de Alternativas Energéticas de Origem Vegetal. Brasilia: STI/MIC.; Nogueira, L. A. H., & Capaz, R. S. (2013). Biofuels in Brazil: Evolution, achievements and perspectives on food security. *Global Food Security*, *2*(2), 117-125.

[65] Nogueira and Capaz, op. cit.

[66] Ibid.

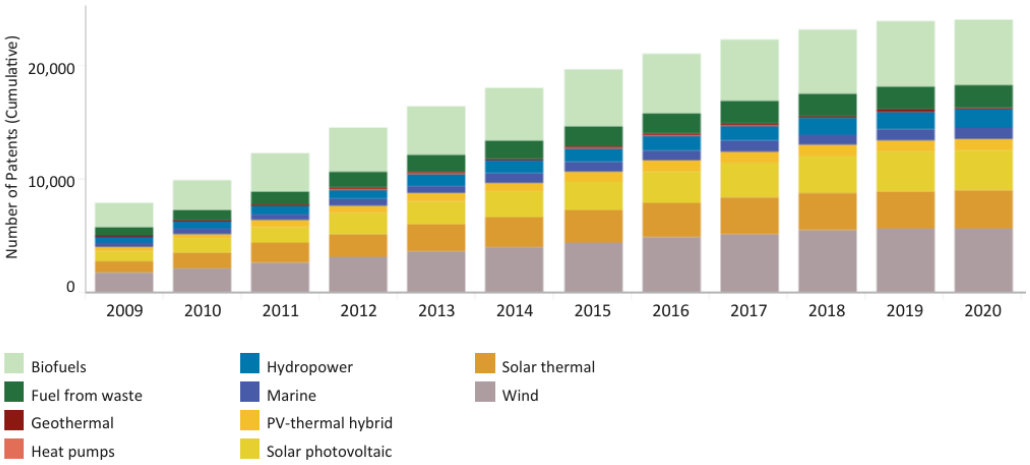
[67] Ibid.

[68] Moraes, M. A. F. D., Costa, C., Guilhoto, J., Souza, L., & Oliveira, F. (2010). Externalidades sociais dos combustíveis. *Etanol e Bioeletricidade: a cana-de-açúcar no future da matriz energética*, *1*.

Worker monitoring the ethanol at a sugar mill and ethanol manufacturing plant, Minas Gerais, Brazil, 2008. / T photography (Shutterstock)

On a less positive note, R&D capacity in the renewable energy sector remains quite low in Latin America and the Caribbean compared with global levels, with only 2.5% of globally renewable energy patents being filed in the region in 2020. Although the number of renewable energy patents have been increasing steadily, they have increased at a slower pace than the world total and reveal a declining relative share of global renewable energy patents since 2010.

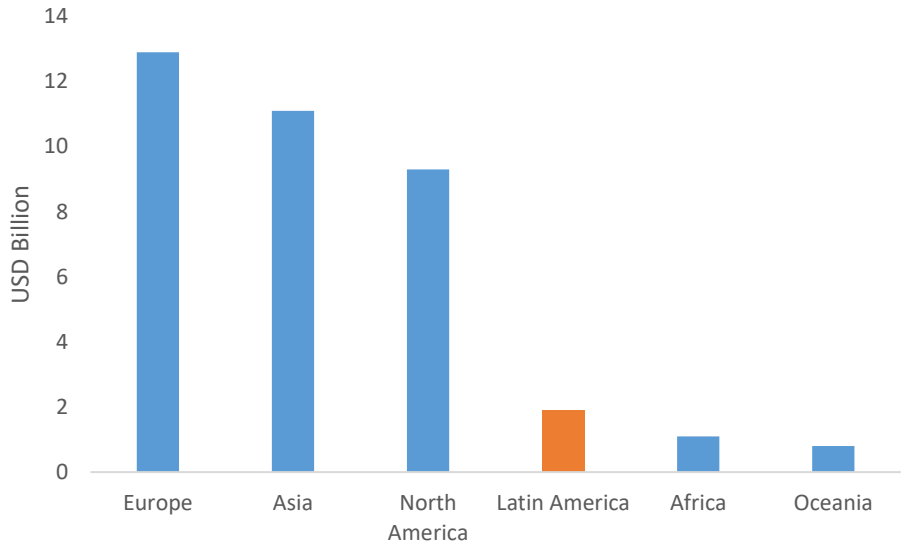
Figure 16. Evolution of Renewable Energy Patents in Latin America, 2009-2020 (Cumulative)



Source: IRENA database

In the wind energy sector more specifically, no Latin American country features in the top 10 countries investing in wind turbine-related R&D, and the planned investments in R&D for the decade 2019-2028 lag far behind Europe, Asia, and North America (see Figure 17).

Figure 17. Planned Global Wind Energy R&D spending (public and private), 2019-2028



Source: Author calculation based on Intelstor data

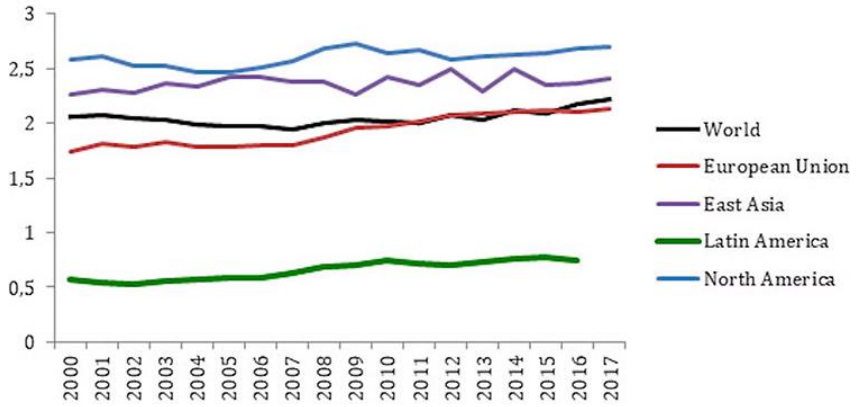
Latin America's extremely low R&D shares around renewable energies mirror a larger regional trend. As shown in Figure 18, the region's average R&D expenditure (as a share of GDP) is amongst the lowest in the world (<0.6%), falling well below the world average (>2%). It is undeniable that more and better-oriented public R&D efforts and their coordination with the private sector need to take place.[69] In addition, in almost every Latin American country, more than one half of the existing R&D expenditure is financed through public funds, where the share in Europe and North American countries (excluding Mexico) tends to be below 35%.[70] In Argentina, Ecuador, Cuba, and Costa Rica, the share of public funding in R&D exceeds 70%.[71] Moving forward, finding ways to encourage further complementary private financing for R&D will be essential in making the most of the economic and trade opportunities that arise from the low-carbon energy transition.

[69] Perez, C. (2008). A vision for Latin America: A resource-based strategy for technological dynamism and social inclusion. *Globelics Working Paper Series*.

[70] RICYT- Red de Indicadores de Ciencia y Tecnología Iberoamericana e Interamericana (2022) database. Accessible at www.ricyt.org/indicadores

[71] Ibid.

Figure 18: Expenditure on Research and Development by World Region (% GDP).



Source: Author's calculations based on data from the World Development Indicators

Downstream value addition: The drive towards Green Hydrogen

Latin America has a unique opportunity to develop a competitive green hydrogen industry from electricity produced with renewable resources, thereby playing a critical role in the global push for decarbonisation. Hydrogen, an industrial gas used widely for over a century, is mostly produced by separating water into its constituents, hydrogen and oxygen, from fossil fuels. However, so-called 'green' hydrogen can be produced using renewable power to provide a zero-carbon energy source. Although it is still an emerging technology that bears some risks and uncertainty, green hydrogen is increasingly considered a critical enabler of the global transition to sustainable energy and net-zero emissions economies.

Latin American countries are well poised for green hydrogen development. The rising global demand for low-carbon hydrogen represents an important window of opportunity for Latin American countries to export low-carbon hydrogen. In the region, Chile was the first country to unveil a hydrogen development strategy (see Box 3) and has been followed by Brazil, Colombia, and Panama (which have also unveiled a hydrogen strategy or have sent their hydrogen development roadmap for public consultation). Several Latin American countries, including Argentina, Brazil, Chile, Colombia, and Mexico, possess suitable characteristics for the competitive production of green hydrogen from renewable energies. The International Energy Agency identified more than 800km, mostly in Northern Chile, Brazil, Patagonia, and Northern Mexico, where hydrogen production costs could be below 1 USD by 2050, making production very competitive by global standards.

Green hydrogen also provides an opportunity for Latin American countries to add value to local renewable energy production, increase the security of supply, and trade zero-carbon energy more cost-effectively given hydrogen's versatility as an energy carrier. The potential competitiveness of Latin American countries in renewable energy production and the global need for clean energy carriers provides an opportunity for domestic hydrogen production to rival the size of the fossil fuel sector, which is most likely to decline in importance in coming decades (see Section 3.1). If timely

and effective action is taken, Latin America's green hydrogen investments, production, and use can lead to the creation of dynamic economic and trade ecosystems throughout the region.

Some Latin American countries already have experience producing hydrogen from fossil fuels. However, in the long term, the transition to hydrogen production from renewable energy will be essential. In the short-term so-called blue hydrogen demand and infrastructure could potentially be developed in the region by coupling existing hydrogen production from natural gas (in Argentina, Brazil, Peru, and Trinidad and Tobago) with carbon capture, utilisation, and storage.[72] However, this production method is expensive, and the technological requirements differ to some extent from those for green hydrogen. In the long term, therefore, transitioning to the production of hydrogen from renewable energy remains important, as the current emissions of hydrogen produced from 'dirty' sources in the region are currently very high - especially in Trinidad and Tobago, where emissions from (grey) hydrogen production (that reached 16 megatonnes (Mt) CO2 /yr in 2019)- represent one of the major sources of carbon emissions in the country.[73] Currently, most of the regional production of hydrogen is from dirty sources (natural gas, 85%). In 2018, the regional demand for hydrogen reached about 4 gigatonnes (Gt), 40% of which was driven by demand in Trinidad and Tobago, followed by Mexico, Colombia, and Brazil, to produce ammonia production, oil refining, methanol production, and steel making.[74]

There is a diverse set of opportunities and end-uses of green hydrogen across the region.[75] In the case of Trinidad and Tobago, which is already a major (grey) hydrogen producer, existing capabilities could be leveraged toward the production of green hydrogen. In Brazil, where considerable biofuel production capacity exists, biofuels can provide an energy source for hydrogen production. In countries such as Brazil and Chile, where mining accounts for one quarter of national diesel consumption, Ecuador, and Peru, the production and use of green hydrogen can help reduce emissions associated with the mining sector. In countries that have almost fully decarbonised their power generation, such as Costa Rica, Panama, Paraguay, and Uruguay, hydrogen production and use has the potential to develop exports, as well as help replace fossil fuels in transport activities if/when hydrogen-related technology becomes cost-effective relatively to fossil fuel imports. Lastly, in the case of Panama, given the country's strategic location to international shipping, there could be an opportunity to become a regional hub for hydrogen distribution and trade.

Green hydrogen is still at an early stage of development in the region, and challenges to scaling-up of production and use persist, but different pilots and demonstration projects have been successfully launched. On the technological front, Argentina has been a pioneer in producing green hydrogen. Since 2008, the Hychico project in Patagonia has been producing both hydrogen and oxygen (sold in the industrial gas market) through water electrolysis powered by one of the country's first wind farms.[76] Other pilot projects for green hydrogen production in the region include the Ad Astra Rocket project in Costa Rica established in 2011, which is used to power a fuel cell bus

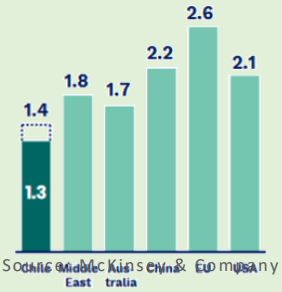
[72] IEA 2021, op. cit.
[73] (ibid.).
[74] (ibid.).
[75] IEA (2021), *Hydrogen in Latin America*, IEA, Paris
[76] It has two electrolysers with a total capacity of 120 Nm3/h of hydrogen and 60 Nm3/h of oxygen (see Hychico.com.ar).

and four fuel cell light-duty vehicles; and the Cerro Pabellón microgrid pilot project in Chile's Atacama Desert, which has been operational since 2019.

Box 3. Chile's Green hydrogen strategy

Chile has made considerable efforts towards producing a competitive green hydrogen industry for local use and exportation. In the past six years, Chile has increased the generation capacity from renewables five-fold and aims to achieve a 70% share of renewables in electricity generation by 2030. Solar generation in the central part of Chile is already more competitive than fossil-powered electricity generation.

The quality and abundance of the renewable energy resources found in Chile can enable large-scale competitive production of green hydrogen. Estimates even suggest that green hydrogen produced in the Atacama Desert (site of the most powerful solar radiation on the planet) and in the Magallanes Region (which has considerable wind energy potential) will achieve the lowest levelised cost of production globally by 2030.



Source: McKinsey & Company

Chile was the first Latin American country to unveil a national hydrogen strategy which sets an ambition to export 11 USD billion by 2035 and 24 USD billion by 2050.

The first phase of green hydrogen production will include domestic usage with existing large energy or hydrogen demand, thereby replacing imported ammonia and grey hydrogen currently used in oil refineries. However, in the medium to long term, it is also anticipated that locally produced green hydrogen can be used for heavy and long-distance transportation for fleets and machinery and be available for export. The opening of new export markets in the long term (such as green hydrogen to decarbonise the shipping and aviation industries) will allow a massive scale-up of production.

Chile requires a multi-stakeholder approach to build competitive national capabilities around hydrogen, so it can be adopted in the country's strategy, which aims to foster industry-academia linkages, identifying and promoting the technical skills required along the value chain of green hydrogen. Chile's hydrogen strategy also includes an R&D roadmap to solve local implementation challenges, involving both public and private sectors and a key role of the Clean Technologies Institute, an innovation platform with public funding of up to USD 193 million.

Source: Ministry of Energy of Chile, National Green Hydrogen Strategy[77]

Stronger policy tools and a regional approach will be key to the success of Latin America's green hydrogen sector. Much more remains to be done to achieve Latin America's hydrogen ambitions, and several barriers to developing and scaling hydrogen production exist. These include asymmetries of information, a lack of coordination between supply and demand, technological and financial risks, as well as cost gaps with fossil-powered solutions.[78] Introducing new technology to the country's energy systems will require considering policy efforts at the national level, but also at the regional level. Indeed, the long-term development and success of the green hydrogen industry hinges on international and regional cooperation to establish recognised certification schemes to

[77] Ministry of Energy of Chile, *National Green Hydrogen Strategy*. Accessible at: https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf
[78] IEA 2021, op. Cit.

foster low carbon hydrogen production and demand; and exploit synergies and economies of scale to establish regional supply chains and ensure productivity gains.[79] Such a regional approach can draw inspiration from what has already been adopted in North-West Europe, where several countries established a forum to discuss the development of a regional energy market.[80]

Downstream value addition: Opportunities for low carbon services

As the global low carbon economy expands, there will be new market opportunities for the development of low carbon/decarbonised industries and services. As countries pledge to decarbonise their consumption and productive systems, there will be higher demand and a market premium for goods and services that have a lower carbon and material footprint. It is estimated that by 2030 the market for low-carbon goods will be worth more than USD1 trillion per annum – an increase of seven to 12 times compared to today.[81] Countries that undertake early efforts towards gaining competitiveness in low carbon goods provision will be positioned to gain the biggest market share, which is why Latin American countries need to take action now.

From this perspective, Latin American countries have an opportunity to leverage their renewable energy and green hydrogen potential to be early movers in the provision of a range of decarbonised goods and services, including low carbon manufacturing, mining, and technology services. Low carbon manufacturing can be referred to as the manufacturing process that lowers carbon emissions intensity and uses energy and resources efficiently.

In a decarbonizing world, it will make sense for energy-intensive activities to take place near specific locations that are abundant in renewable energy.[82] In recent decades, due to the ease of transporting fossil fuels, energy-intensive industries such as steel have been dominated by energy-poor countries such as Japan and South Korea. However, clean energy sources (apart from nuclear power) are unevenly distributed and costly to transport (including through green hydrogen production, which is an energy-intensive process).[83] In that sense, first movers that develop the right ecosystem for green industrialisation are bound to come out ahead, which could be good news for countries in Latin America that can provide renewable energy sources at competitive costs.

A range of technology services such as data cloud services or cryptocurrency farming also face challenges due to their carbon intensity, which could provide interesting market opportunities in Latin America. For instance, in 2015, Google opened a data centre in Santiago, Chile, which is powered via a solar energy field in the Atacama Desert. Google contracted up to 80 MW of solar power from Acciona Energy to secure sufficient energy to power the centre.[84] Looking ahead, the provision of cheap, reliable, and clean energy could be a key asset –and requirement- to further attract foreign investment in energy-intensive technology services. Expanding renewable energy capacity will be necessary to ensure that new investments in energy-intensive activities do not

[79] Ibid.

[80] Ibid.

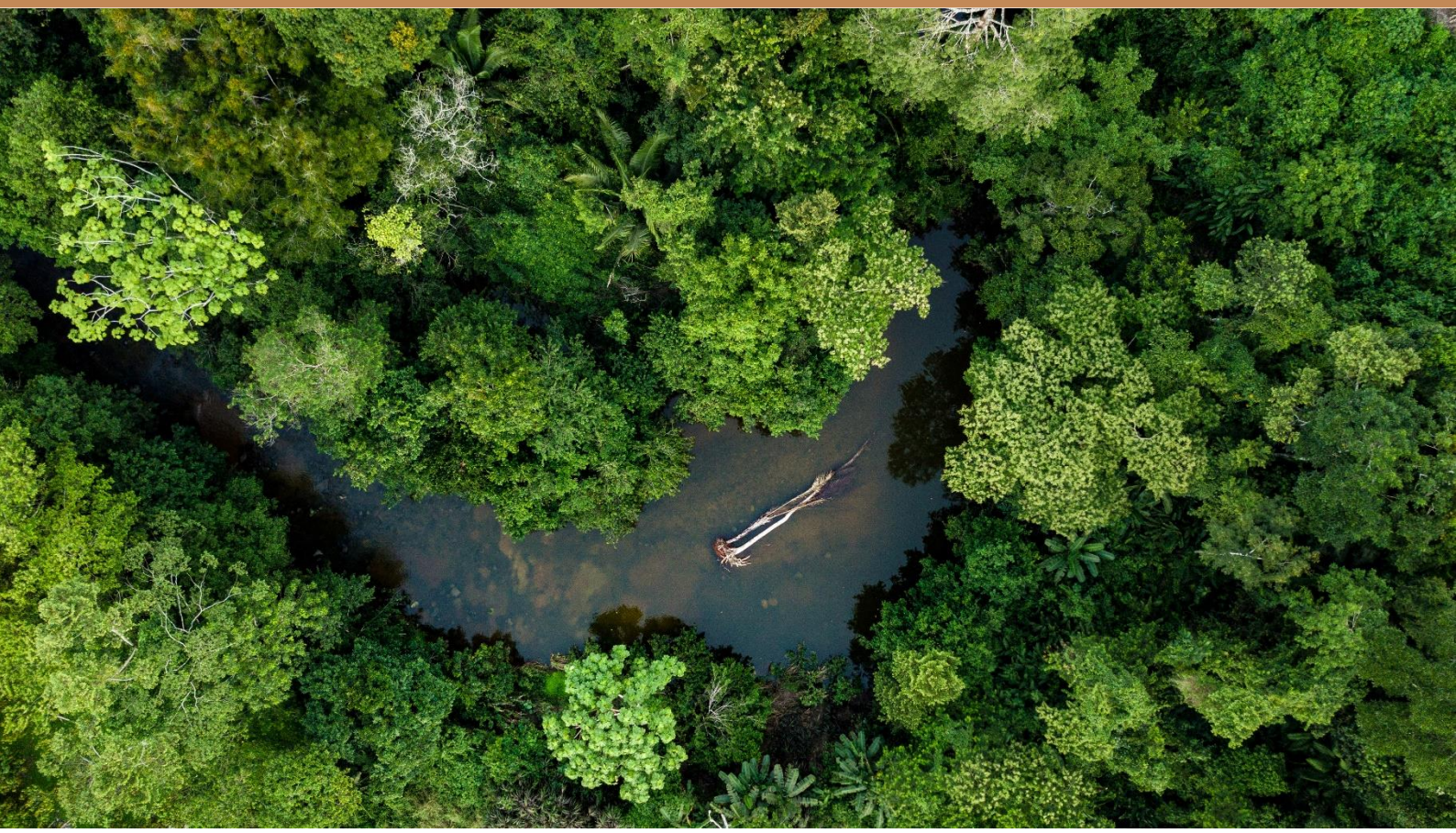
[81] Vieira, H. (2017). Low-carbon services can enhance the UK's economic prospects. August 28. *LSE blogs*

[82] Hausmann, R. (2021). 'Green Growth at the End of the Flat World'. *Project Syndicate.* December 9.

[83] Ibid.

[84] Bebon, J. (2017) Google Powers Chilean Operations With 100% Solar. January 20. *Solar Industry.*

redirect existing clean energy from other activities that would have to revert to dirtier energy sources to supplement energy needs.



Aerial photo of a river in **A**mazon rainforest jungle in Peru. / qualtaghvisuals (Shutterstock)

Biodiversity in the context of trade

Overview of the central role of biodiversity

Latin America is characterised by singular physical geography and natural ecosystem, the conservation of which is of central importance for sustainable development. The region contains seven of the 13 most biodiverse countries in the world; namely, Brazil, Colombia, Mexico, Peru, Ecuador, Bolivia, and Venezuela.[85] The interplay between the region's biodiversity and economic activity is a vitally important.[86] For many years, this interplay tipped in favour of resource extraction and use. Nevertheless, the growing global focus on sustainable development and ecological sustainability prompts a discussion between the continued reliance on extractive economic activity and the desire to preserve the region's unique natural treasures.[87] Against this backdrop, it is worth exploring the role of biodiversity-based services as providing a sustainable economic alternative to deforestation and environmentally damaging extractive activities in the region.

[85] Lebdioui A. (2022) Learning from nature to reconcile economic upgrading with biodiversity conservation? Biomimicry as an innovation policy. Centre for Climate Change Economics and Policy Working Paper 402/Grantham Research Institute on Climate Change and the Environment Working Paper 37. Accessible at https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2022/01/working-paper-375-Lebdioui.pdf

[86] Purkey D. (2021) 'Biodiversity', in LatAm Outlook 2021. London: Canning House.

[87] Ibid.

Given Latin America's endemic biodiversity and unique natural ecosystems, biodiversity-based trade and innovation services can be a transformative force for boosting economic development and trade. Traditional conservation approaches and the policy debates on biodiversity protection have tended to be limited in terms of how the region's unique biodiversity could be leveraged as a lever for sustainable development. There are several ways in which the region's biodiversity influences trade opportunities, not only in terms of ecotourism, but also in carbon markets and bio-innovation, which explains the increasing attention devoted to the potential development of bioeconomy strategies in Latin America. The bioeconomy can be defined as "the production, utilisation and conservation of biological resources, including related knowledge, science, technology, and innovation, to provide information, products, processes and services in all economic sectors aiming toward a sustainable economy".[88] One key pillar of the development of a bioeconomy in Latin America lies in the promotion of innovation processes that contribute to the diversification of economies and generate new value chains.[89]

Despite its considerable potential, the biodiversity-based innovation sector has been nascent across Latin America. Some countries have shown laudable efforts to capitalise on the innovation value of biodiversity through bioprospecting. As further discussed in this section, the most well-known initiative took place in the 1990s in Costa Rica, with the creation of the National Biodiversity Institute (INBio), which worked under the premise that a country will be able to conserve a major portion of its biodiversity if this generates enough intellectual and economic benefits to make up for its maintenance.[90]However, across the region, only a few government policies exist, and entrepreneurship has so far been minimal compared with the potential.

Carbon markets and compensation for ecosystem services

Latin American countries are currently providing a range of ecosystem services (such as carbon storage, watershed protection, conservation of fauna and flora) from which the whole world benefits raising a question about compensation. Biodiversity and natural ecosystems are among the region's most valuable assets, and policy efforts exist to marketize and compensate for their protection. For instance, Costa Rica's pioneering Payments for Environmental Services Program (PES) is a financial mechanism whereby landowners receive direct payments for the ecological services that their lands produce when they adopt environmentally friendly land uses and forest management techniques.[91]

Payments for Ecosystem services also provide a valuable trade and employment opportunity in the context of post-conflict local development in biodiverse areas, such as in Colombia. Colombia hosts

[88] International Advisory Council of the Global Bioeconomy Summit 2018. (2018). Communiqué, Global Bioeconomy Summit 2018, Innovation in the Global Bioeconomy for Sustainable and Inclusive Transformation and Wellbeing. 20 April 2018, Berlin Germany.

[89] Rodríguez, A. G., Rodrigues, M. D. S., & Sotomayor Echenique, O. (2019). Towards a sustainable bioeconomy in Latin America and the Caribbean: Elements for a regional vision. Santiago: ECLAC.

[90] Mateo, N., Nader, W., & Tamayo, G. (2001). Bioprospecting. Encyclopedia of biodiversity, 1, 471-488.

[91] Malavasi, E. O., & Kellenberg, J. (2002). Program of payments for ecological services in Costa Rica. In Building Assets for People and Nature: International Expert Meeting on Forest Landscape Restoration, Heredia, Costa Rica (Vol. 27, pp. 1-7).

10% of the world's biodiversity.[92] However, access has been restricted in recent decades due to the presence of civil conflict. With the return of peace, public investment has focused on security and economic recovery, which has increased pressure on natural capital and deforestation.[93] The government's challenge is to manage the return of millions of displaced people to rural areas and provide a sustainable livelihood that enhances natural wealth, as an alternative to extractive practices that may be effective in feeding families in the short run but could undermine intergenerational wealth and future development prospects.[94] Accordingly, Colombia's Green Growth Strategy (see Box 5) aims to enhance the efficient use of natural capital including water, soil resources, and energy, as well as to develop new economic opportunities through enhancing the local bioeconomy. Within this framework, the Colombian Government has proposed PES as a sustainable way to promote economic alternatives (especially biodiversity-enhancing productive projects) to populations affected by the armed conflict. Evaluations reveal that when accounting for the value of biodiversity, the proposed PES represents a strong investment proposition with a net present value of USD4.4 billion.[95] Such benefits are regionally differentiated, which help inform the spatial targeting of policies to maximize economic, environmental, and social outcomes.[96]

It needs to be stressed that mechanisms to marketize the value of ecosystem services provided by local communities have often been limited to national boundaries and local communities often struggle to receive remuneration from the international community for this 'tradable' service. For instance, Ecuador's Yasuní-ITT Initiative directly confronted the issue of international ecosystem services by leaving oil in the ground in the Yasuní National Park, one of the most biodiverse spots in the world. The initial proposal by the Government of Ecuador involved keeping almost one billion barrels of petroleum underground if the international community contributed with at least one half of the opportunity cost of exploitation.[97] The initial support from international institutions, European governments, and NGOs worldwide did not translate into concrete action, and the 2008/9 financial crisis added pressure on Ecuador's international sources of financing, which led president Rafael Correa to pursue his backup plan to drill for oil if contributions were not received.[98] However, despite this failure, several lessons can be learned for the future success of similar programmes, especially regarding the need for international coordination and clearer legal frameworks to compensate for biodiversity protection from which the whole world benefits. Even though many ecosystem services are not readily transacted and valued by the market, they are still economically valuable and there is increasing research and policy discussion that aims to determine the value of

[92] Moreno, L.A., Andrade, G.I., Gómez, M.F., (2019). Biodiversidad 2018. Estado y tendencias de la b biodiversidad continental de Colombia. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Bogotá, D. C

[93] Bustos, C., Jaramillo, M. (2016). La paz en Colombia: una oportunidad clave para un desarrollo sostenible. Ojo Al Clima. Sep 17; McNeish, J. - A., (2017). Extracting justice? Colombia's commitment to mining and energy as a foundation for peace. The International Journal of Human Rights 21, 500 –516.

[94] Banerjee et al., op. cit.

[95] Ibid.

[96] Ibid.

[97] Larrea, C., and L. Warnars (2009). 'Ecuador's Yasuni-ITT Initiative: Avoiding Emissions by Keeping Petroleum Underground'. Energy for Sustainable Development, 13(3): 219–23

[98] Ibid.

(both market and non-market) derived from the management and protection of ecosystems (see RED+ programmes for instance).[99]

Increasing attention is devoted to carbon markets and carbon pricing as an interesting way forward for generating trade value from biodiversity protection.[100] Putting a price on pollution can be an important source of government revenue: in 2019, governments globally raised USD45 billion this way.[101] Domestic carbon pricing initiatives have been strengthened as jurisdictions around the world adopt more ambitious mitigation targets and introduce associated policy tools.[102] Those countries include Mexico, Chile, and Colombia, which have begun to use – or are considering using - carbon pricing and emission trading systems as part of a broader strategy to decarbonize their economies. For instance, the pilot phase of Mexico's national carbon market started in 2020, representing the first emissions trading system (ETS) (see Glossary for definition) in Latin America.[103]

Beyond domestic decarbonization goals, for carbon markets to be leveraged as a trade tool, carbon emissions trading systems need to cut across country and continental boundaries. There has been increased cooperation among jurisdictions to align their carbon markets (such as the EU and Switzerland for instance). Similar cooperation is needed within and beyond Latin America to leverage carbon markets as a source of foreign exchange revenues and to receive compensation for ecosystem services from international trade partners – rather than local actors exclusively.

Reliance on ecotourism: benefits and limitations

Ecotourism's appeal rests on its potential to provide local economic benefits while maintaining ecological resource integrity through low-impact, non-consumptive resource use.[104] Ecotourism, which aims to reduce the environmental footprint of tourism activities, is defined as the promotion of responsible travel to natural areas, and conservation of the environment, while improving the well-being of local people .105 Trade-in ecotourism services are considered a promising way to support the dual challenge of sustainability and economic diversification.[106] It has become increasingly popular across Latin America to promote environmentally friendly growth. Both Costa Rica and Ecuador (in the Galapagos Islands more particularly) are among the major ecotourism destinations in the world (see Figure 19).

[99] Siikamäki, J. and Epanchin-Niell, R. (2015). Mapping the Value of Ecosystem Services in Latin America and the Caribbean. *Resources Magazine*, February 17.

[100] Stern, N., & Stern, N. H. (2007). *The economics of climate change: the Stern review*. Cambridge University press.

[101] World Bank (2020) "*State and Trends of Carbon Pricing*. World Bank, Washington, DC.

[102] Ibid.

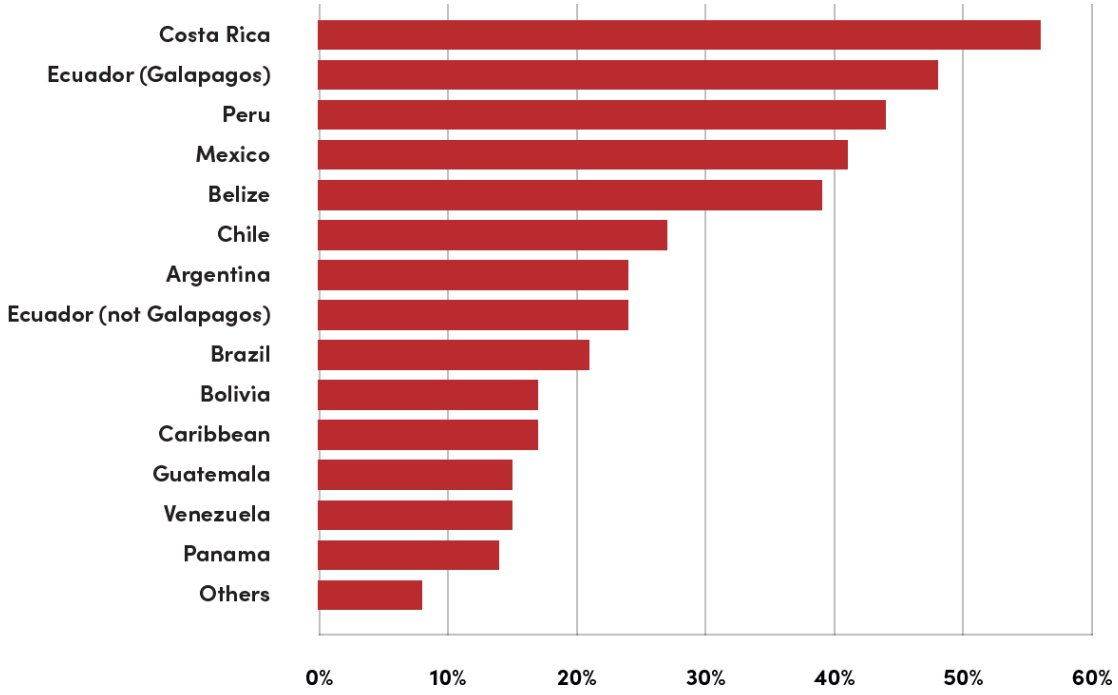
[103] The ETS pilot programme will run for three years, giving participants time to familiarize with the carbon market, letting regulators test its overall design, and sending an initial carbon price through the economy (World Bank, op. cit. 2020)

[104] Stem, C. J., Lassoie, J. P., Lee, D. R., & Deshler, D. J. (2003). How eco is ecotourism? A comparative case study of ecotourism in Costa Rica. Journal of sustainable tourism, 11(4), 322-347.

105 The International Ecotourism Society - TIES (2022). What is Ecotourism?. Accessible at: https://ecotourism.org/what-is-ecotourism/

[106] Hübler, M. (2019). How trade in ecotourism services can save nature: a policy scenario analysis. *Development Southern Africa*, *36*(1), 127-143.

Figure 19: Percentage of US-based ecotourism operators offering products by country.



Source: Purkey D. (2021) 'Biodiversity', in LatAm Outlook 2021. London: Canning House.

Ecotourism generates around 3,5 million jobs in Latin America and the Caribbean, while tourism, in general, generated around 19 million jobs in 2018, or 8% of total employment.[107] There is evidence that nature-based tourism can accelerate poverty alleviation, especially in remote areas

[107] Saget et al. op cit.; WTTC, 2019b

where alternative sources of job creation are scarce, while providing foreign exchange across several economic sectors.[108]

People exploring a wild nature area by rowing boat. Ecotourism concept. Tortuguero National Park, Costa Rica. / Marco Lissoni (Shutterstock)

Nevertheless, overreliance on ecotourism has often posed important environmental and developmental risks.[109] Ecotourism cannot be viewed as a benign, non-consumptive use of natural resources in biodiverse nations because scale influences tourism's negative impacts, and where ecotourism dominates local economies, towns may become economically vulnerable.[110] This is why it is crucial to identify alternative ways to capture the economic value of biodiversity conservation to complement -and at times supplement- ecotourism. In Costa Rica, where ecotourism has gained appeal as a strategy to align conservation and development, assessments of its impact on the country have been mixed. The development of ecotourism in Costa Rica resulted from the Biodiversity Law (No. 7788, 1998) and complementary entrepreneurship training programmes (including business development with a focus on environmental and social responsibility) tailored to the needs of each community). On the one hand, some assessments reveal that the tourism industry in Costa Rica (and the Osa Peninsula in particular) tends to hire more local people than other sectors within the region, while providing jobs with higher salaries, including for young people

[108] IDB, 2017

[109] Purkey, op. cit.

[110] Jacobson, S.K. and A.L. Lopez. 1994. Biological Impacts of Ecotourism: Tourists and Nesting Turtles in Tortuguero National Park, Costa Rica. Wildlife Society Bulletin 22(3):414-419.

and women with children (thanks to a more flexible working schedule).[111] On the other hand, some negative impacts of the ecotourism industry in Costa Rica have also been raised, and include solid waste generation, air pollution, habitat destruction, and sociocultural ills.[112] The risks associated with dependence on ecotourism are also well demonstrated by the experience of the emblematic Galapagos Islands, which have become overdependent on tourism as a source of funding for biodiversity protection.

Figure 20. Consequences of over-reliance on tourism in the Galapagos

San Cristobal, Galapagos Islands. Credit: Amir Lebdioui

Environmental damage

In 2007, due to the uncontrolled development of tourism, the Galapagos were even included in the Danger List of the UNESCO World Heritage Sites

Limited value-added services & skilled jobs

It is highly unlikely that ecotourism can generate sufficient skilled jobs and knowledge spillovers to act as an engine of growth and therefore a sufficiently attractive alternative to biodiversity exploitation/ extractive activities.

Revenue Volatility

Revenues from tourism are highly vulnerable to external shocks, as shown by the COVID crisis. The number of tourists visiting the islands dropped by 75% between 2019 & 2020. While nature has gained some relief, the revenue drop jeopardised local livelihoods, as well as the public budget to maintain local natural ecosystems.

[111] Hunt, CA. W. H. Durham, L. Driscoll & M. Honey (2015) Can ecotourism deliver real economic, social, and environmental benefits? A study of the Osa Peninsula, Costa Rica, Journal of Sustainable Tourism, 23:3, 339-357

[112] See Stem, C. J., Lassoie, J. P., Lee, D. R., & Deshler, D. J. (2003). How 'Eco' is ecotourism? A comparative case study of ecotourism in Costa Rica. Journal of sustainable tourism, 11(4), 322-347.; Koens, J. F., Dieperink, C., & Miranda, M. (2009). Ecotourism as a development strategy: experiences from Costa Rica. Environment, Development and Sustainability, 11(6), 1225-1237.

Ecotourism is also most effective as a conservation and development tool when it is embedded in a broader process of capacity building and national strategy. Costa Rica has taken important steps in this direction. For instance, Costa Rica's Forest Law (adopted in 1996) recognises four environmental services provided by forest ecosystems: (i) mitigation of GHG emissions; (ii) hydrological services, including the provision of water for human consumption, irrigation, and energy production; (iii) biodiversity conservation; and (iv) provision of scenic beauty for recreation and ecotourism. Ecotourism in Costa Rica has been embedded in a national vision for leveraging the economic value of nature, and the government has also shown great ambition to leverage the innovation value of biodiversity (although almost entirely restricted to bioprospecting), as discussed in the next section.

Biodiversity-based Innovation

There have been both successes and failures in leveraging the innovation value of biodiversity in Latin America. The potential development of biodiversity-based innovation activities in Latin America is considerable because of

- the region's access to a large portion of the world's endemic biodiversity, meaning that it cannot be found elsewhere.
- the fact that the transport of genetic resources is often restricted by legal frameworks anchored in the Nagoya Protocol on Access and Benefit Sharing.
- the existence of related frontier research capabilities domestically, such as the mapping and discovery of new species, which often involved partnerships between local and foreign research teams.[113]

The natural biodiversity of the Latin America has inspired several interesting inventions and innovations in the space and holds great promise in terms of potential and future innovations. Nevertheless, notwithstanding these countries' considerable potential for nature-based technological innovation, the persistence of market and institutional obstacles remain key challenges to be addressed.

Some countries have addressed this agenda more than others. Governments in Costa Rica, Mexico, Colombia, and Chile have taken non-negligible steps to support biodiversity-based innovation research and firm-level activity, while policy support is quasi-non-existent in other countries of the region. Despite being the most biodiverse country in the world, Brazil has lagged in building up a nature-inspired innovation ecosystem. This can be partially explained by the economic downturn of recent years, which led many organisations to cut R&D capabilities and a lack of governmental investment in biomimicry programmes.[114] Biodiversity-based innovation is also an area of great potential for Chile given its diverse ecosystem and number of endemic species. For example, over

[113] The need for foreign firms and researchers to collaborate with local researchers is notably due to restrictions in the access to local genetic material and permits required from the Ministry of Environment, and the fact that local teams often have better knowledge of the local natural ecosystem.

[114] Lebdioui (2022), op.cit.

62% of Chile's marine species are endemic to the country and not found elsewhere.[115] Nevertheless, the concretization of a biodiversity strategy has remained at an early stage.

Costa Rica has formulated policy initiatives towards capturing the economic value of biodiversity, including some efforts towards capturing the innovation value of biomimicry potential. In the context of the recovery from the COVID-19 crisis, several key initiatives to promote bio-innovation were initiated, such as the National Bioeconomy strategy, launched in 2020, to promote a green knowledge economy; and the Biomaterials hub, funded by the IDB Lab and led by Costa Rica's Investment Promotion Agency (CINDE), to promote R&D around biodiversity and sustainability for domestic firms that do not have R&D capabilities. These efforts remain focused on utilising natural assets as a source of genetic material rather than a source of inspiration for innovation. Except for four university-level research projects at the Universidad de Costa Rica, LANOTECH, Veritas and Universidad Nacional, there are presently no biomimicry initiatives operating in Costa Rica.[116] None of these projects have evolved into businesses to date.

In the Galapagos Islands, conscious of the downsides of an over-reliance on ecotourism, the local government has attempted to develop research and innovation activities to replace tourism as the main source of local livelihoods and funding for biodiversity protection (Norman Wray, Governor of the Galapagos Islands, personal interview, April 2021). While 85% of the Galapagos' economic activity used to depend on tourism, with the pandemic, "it has become essential to recover economic activity in a way that is productive, inclusive, resilience, and environment-friendly" (Luis Felipe López-Calva, UNDP Director for Latin America, cited in UN 2020). Holding the world's second largest marine reserve, the Galapagos Islands are often referred to as 'the largest live biodiversity laboratory in the world.' However, this potential has been mostly unfulfilled to date, given the limited local R&D capabilities to conduct biomimicry activities, such as the lack of specialised local universities. As a result, local populations have struggled to gain the required skills for the development of a local nature-based innovation ecosystem.[117] As a first step towards a new innovation-based development model, an innovation hub was created in May 2021 under Ecuadorian law. This innovation hub is the first public policy that aims to promote innovation activities in the Galapagos. Though the impact this initiative will have on the long-term conservation efforts is not yet clear, it represents a promising step forward because it identifies synergies between biodiversity and innovation, as well as its orientation as a potential alternative source of financing for conservation. However, in the rest of Ecuador, public policy support for nature-based innovation remains quasi non-existent. As a result, most bio-innovation activities appear to be university spinoffs that have not managed to scale up due to the lack of available funding and the high cost of laboratory operations.[118]

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[115] ibid.

[116] The researchers leading these projects study the cooling properties of long-horned beetles, the adhesive properties of hydrogel secreted by a specie of worms, and antibacterial properties of *pineapple peel (Personal communications with lead researchers; October/November 2021)*.

[117] Low internet connectivity is also an obstacle to the development of innovation activities in the islands. A plan to install fibre optic cable in 2022 is expected to increase connectivity.

[118] For instance, Anuka is a firm that takes advantage of the capacities of endemic volcanic microalgae of Ecuador, which offers more resistance to bacteria and to fungus than most microalgae found around the world, to produce biofilters with high carbon capture properties. in the environment. Anuka developed as a university-spinoff but the growth of the firm and the development of the

Interviews with a range of stakeholders in both Costa Rica and Ecuador between January and November 2021 shed light on several bottlenecks hindering the development of bio-innovation activities and their commercialisation. These include:

- Limited bioprospecting and value derived from it to date
- Lack of a critical mass of specialised human capital due to limited interdisciplinary university training related to bio-innovation
- Inadequate financial support
- Administrative hurdles and difficulty obtaining permits to conduct research.

Addressing these coordination failures that are stunting the growth of bio-innovation activities requires the strategic use of policy interventions. For instance, the provision of funding, facilitation of access to study biodiversity, and the promotion of integral and interdisciplinary education programmes in bio-innovation processes will be crucial for the successful development of local nature-based innovation ecosystems. The policy implications of these findings are discussed in the next section.

commercial phase was stunted by the lack of domestically available funding, as well as the high costs of operating laboratories in Ecuador.

Way forward: Policy recommendations

Capacity building at the national level

Green Industrial Policies

Far-sighted industrial policies will be key in helping realise the trade opportunities that arise from the global decarbonisation agenda. Green transitions provide an opportunity to diversify economies, increase industrialisation and leave the commodity dependence trap behind by fostering the so-called "industries without smokestacks".[119] In that context, *green* industrial policies are increasingly acknowledged as central to driving the structural transformation toward a more sustainable and greener economic system when focused on energy transition technologies, especially in light of the important and long-term investments that green activities need.[120] Such policies would go beyond the mere adoption of low carbon technologies but also entail the promotion of high value-added activities that feed into low carbon technology value chains. From this perspective, some of the strategic areas where industrial policy in the region could focus on include critical minerals supply chains, clean energy and green hydrogen, low carbon extraction methods and resource efficiency, high value-added services around low carbon technology sectors and biodiversity-based innovation.

Over the past two years, several Latin American countries have already taken important steps toward green industrial policies (See Boxes 4, 5, 6). For instance, the Government of Costa Rica has recently launched a "bioeconomy strategy" that seeks to address the challenge of COVID-19 via the promotion of a green knowledge economy. The government of Argentina announced its National Green Productive Development Plan aiming to align the country's production with the global climate agenda. The Government of Uruguay launched an Inclusive Green Economy Transition plan, and the Government of Colombia launched a Green Growth policy in 2018.

Industrial policies aim to promote the structural transformation of an economy and are needed to enhance productivity gains and return on investment in private sector activities. It should be stressed that industrial policies and renewable energy solutions need to be tailored to the respective country's conditions to meet the potential. Different objectives can also be adopted based on a country's specific ambitions, time horizon, and starting point in terms of capabilities (see Table 1).

Table 1. Short term and long-term Green Industrial Policies for a Sustainable Transformation

SHORT TERM	
Policy tools	***Examples***

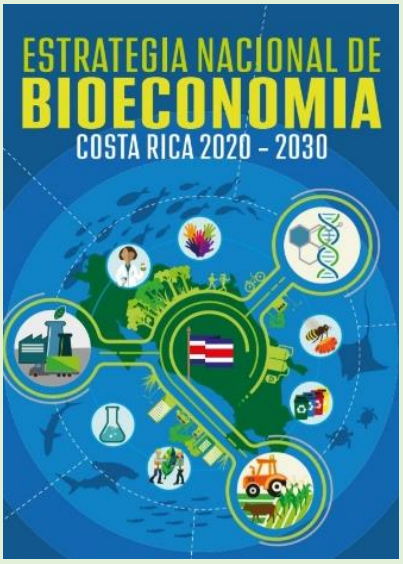
[119] Newfarmer, R., Page, J., & Tarp, F. (2019). *Industries without smokestacks: Industrialization in Africa reconsidered* (p. 480). Oxford University Press.

[120] Anzolin, G., & Lebdioui, A. (2021). Three dimensions of green industrial policy in the context of climate change and sustainable development. *The European Journal of Development Research*, *33*(2), 371-405; Hallegatte, S., M. Fay, and A. Vogt-Schilb (2013), "Green Industrial Policy: When and How", *World Bank Policy Research Working Paper No. 6677*. Washington, DC: World Bank.; Lütkenhorst, W., T. Altenburg, A. Pegels, and G. Vidican (2014), "Green Industrial Policy: Managing Transformation under Uncertainty", *DIE Discussion Paper*. Bonn: Deutsches Institute für Entwicklungspolitik; Hochstetler, K. (2020) *Political economies of energy transition: wind and solar power in Brazil and South Africa*. Cambridge University Press.Rodrik D. (2014), "Green Industrial Policy", *Oxford Review of Economic Policy*, 30 (3),469–491.

Adoption of clear decarbonization goals and roadmap	*Adoption of renewable energy objectives in the short and long term and green economy plans (such as Colombia's Green Growth strategy and Costa Rica's Bioeconomy strategy)*
Establish energy transition objectives, strategies, and industry clusters for emerging technologies.	*Chile's National Hydrogen strategy*
Investment promotion in renewable energy sectors	*Fiscal incentives and credits for investments in renewable energy plants.*
Incentives and adoption of sustainability standards to generate the demand for clean energies and energy-efficient solutions.	*Government regulations to phase-in resource-efficient solutions, such as electric cookstoves (Ecuador).*
Consideration of local content incentives, requirements, and capacity development programmes to foster learning-by-doing for local suppliers.	*Inclusion of local content objectives as part of tenders for renewable energy projects, as in Argentina, Brazil, and Uruguay.*
Establish national competency frameworks for the repurposing of skills from 'dirty' to 'clean' energies.	*Retraining programmes for jobs at risks from the global energy transition (e.g., Argentina's Green Skills programme)*

LONG TERM	
Policy tools	***Examples***
Provide support and incentives for green R&D	*Provision of long-term capital, and non-repayable funding for low carbon technological innovations, certify quality, set standards, offer incubation and support for technology transfer and diffusion (e.g., Chile's new Institute of Clean Technologies)*
Expansion of education and training programmes for skilled human capital accumulation related to green industries	*Expansion of training programmes to provide skills required for the localization of activities related to renewables*
Phase-out local-content requirements when (competitive) supplier base outgrows infant industry protections	*Emphasis on the internationalization of local suppliers through information-sharing, intra-industry dialogue, and capacity development.*
Build regional value chains that foster resilience to exogenous shocks	*The promotion of regional value chains around key renewable energy technologies, utilizing inputs across the regions as well as its critical minerals endowment (e.g., a regional wind energy supply chain)*

Box 4. Costa Rica's bioeconomy strategy



In 2020, the Government of Costa Rica launched a "bioeconomy strategy" that seeks to address the challenge of COVID-19 by promoting a green knowledge economy. It also proposes applying the principles of a circular bioeconomy and the decarbonisation of production and consumption processes. This strategy provides a framework for the orientation of investments, the development of incentives, and synergies between production and the environment.

The strategy, which aims to position Costa Rica as a knowledge-based economy with sustainable production of high added value and the fair and equitable use of its biodiversity, builds on the country's previous commitments to decarbonisation. In February 2019, Costa Rica had already become the first country in Latin America and the Caribbean to announce a comprehensive plan to become a zero-emissions economy by 2050. In addition to sectoral targets, the national decarbonisation plan highlights the role of social inclusion and labour market integration as part of the country's transition towards a green economy.

Box 5. Colombia's Green Growth Strategy

In 2018, the Department of National Planning of Colombia published its Green Growth Policy. The purpose of this policy is to boost the productivity and economic competitiveness of the country by 2030 while ensuring the sustainable use of natural capital and social inclusion in a manner compatible with the country's climate commitments. Through this policy, the government recognises that the current economic model leads to long-term degradation and depletion of the resource base for economic production and generates high costs for the environment and the economy in the long term (estimated at around 2% of GDP). It, therefore, aims to reduce the environmental impacts of productive activities that support development while finding ways to combine economic development with natural resource conservation, inequality reduction, and peacebuilding. The implementation of the policy requires estimated indicative investments of 2.3 trillion pesos (around USD 600 million).

Colombia's Green Growth Policy is articulated around five strategic axes. The first axis is aimed at generating new economic opportunities to diversify the economy through the production of goods and services based on the sustainable use of natural capital. The second seeks to improve the use of natural resources to increase resource efficiency and productivity across economic sectors and minimise the environmental and social impacts generated by the development of economic activities. The third promotes the generation and strengthening of human capital to acquire the knowledge required to support green growth. The fourth establishes strategic actions in the field of science, technology, and innovation support for environment-friendly technologies, thereby generating added value to the national economy. The fifth sets out the actions to ensure the inter-institutional coordination required for the implementation of this policy and the strengthening of capacities to generate quality information for decision-making on green growth and financing sustainable projects.

To provide part funding of these interventions, the Colombian government established the Sustainable Colombia Fund, a multi-donor fund that aims to promote conservation and sustainable use of biological diversity, support rural development, and to support capacity building in conflict zones.[121]

[121] Banerjee et al., op cit.

Green Skills Development and labour market policies

Public actors will have to provide direction and coordination for green skills development and training activities. States have a key role to play as a catalyst of targeted human capital accumulation required for the development of new sectors, especially in countries with few pre-existing capabilities. Such a role is particularly relevant in the context of low carbon transitions, which require the widespread acquisition of 'green' skills. Green skills are skills needed to adapt and develop products, services, and processes to support a sustainable and resource-efficient society. Green skills development needs to be integrated into the wider training and skills development policy rather than being seen as additional or separate from other forms of skills development.[122] The successful transition to a low carbon economy will only be possible by ensuring that workers can adapt and transfer from areas of decreasing employment to other industries and that human capital exists and is maximised to develop new industries.[123]

Box 6. Argentina's Green Productive Development Plan & Green Skills Programme

Argentina's Ministry of Production has announced a National Green Productive Development Plan to align the country's production with the global climate agenda. The Plan includes a set of initiatives to implement that commitment in production systems with a sustainable, inclusive, and environmentally responsible paradigm — across government, the private sector, and civil society.

The four pillars of the Plan are:

- Green Economy, through renewable energy, electro-mobility, knowledge activities, and green industries
- The circular economy
- Sustainability for competitiveness through energy and resource efficiency
- Sustainable industrialization of natural resources and regional integration

On top of the National Green Productive Development Plan, Argentina's national and provincial governments have also made the development of green jobs and green skills a priority. For instance, the provincial government of Santa Fe established a public agency in 2018 to promote the development of green skills.[124] This agency provides training, re-qualifying, and certifying green job competencies. Since 2016, more than 1,500 participants have been trained in green occupations under a programme called "Green Jobs—Caring for the Planet Provides Work" ("Empleos Verdes— Cuidar el planeta da trabajo").[125]

Even in the context of biodiversity-based innovation, for which Latin America has great potential, education policies will be key, because, unlike many other 'traditional' sectors, such activities require a strategy mix of skills (such as biology, chemistry, and engineering skills) which the

[122] Ibid.
[123] OECD (2014). *Greener Skills and Jobs*. Paris : OECD
[124] Saget et al. Op cit.
[125] Ibid.

standard curriculum does not provide.[126] Bio-innovation design processes rely heavily on biological knowledge, but also design and engineering, especially when it comes to abstracting biological strategies into more broadly applicable design principles and implementing them to solve human challenges.[127] However, interdisciplinary bio-innovation technical courses remain scarce across Latin America, and their mainstreaming remains a key foundation for the future of this sector in the region.

Green skills development policies will be key to localising and creating green jobs in Latin America. Green jobs can be defined as decent jobs that contribute directly to environmental sustainability, either by producing environmental goods or making more efficient use of natural resources.[128] The transition to net-zero emissions is expected to create many more green jobs that contribute significantly to poverty eradication and social inclusion. In Argentina for instance, in 2015, green jobs were estimated to represent 7% (650,000 jobs) of formal wage employment, most of which were in manufacturing (38%), transport (29**%**), the agriculture, livestock, forestry, and fisheries sector (9%), and in water supply and waste management (7%).[129]

In conjunction with green skills development policies, labour market policies will also be much needed to ensure readiness to seize green job opportunities and to avoid potential misalignments across time, space, and educational abilities.

Temporal misalignments	***Spatial misalignments***	***Educational misalignments***
when job losses precede job gains at a larger scale. (e.g., closure of a coal plant preceding new activities in renewable energy)	when new jobs are emerging in communities or regions other than those that lose jobs.	when the skills levels or the occupations required under the energy transition were not developed or needed under the previous energy system.

Source: IRENA (2022)[130]

For instance, in Chile, the phase-out coal plan, which implies progressively retiring coal power generation plants between 2030 and 2050, will likely have negative social impacts, such as the loss of 400 to 4,000 jobs.[131] Even though replacing coal with renewable power is expected to create a total of between 2,000 and 8,000 net jobs by 2030, the communities where coal power plants are currently located, and where coal power represents almost 4% of local GDP and 7.1% of employment, will be disproportionately negatively impacted because there are no guarantees that the jobs created in renewable energy sectors will be located in the same place as where jobs are

[126] Lebdioui (2022), op. cit.

[127] Kennedy, E., Fecheyr-Lippens, D., Hsiung, B. K., Niewiarowski, P. H., & Kolodziej, M. (2015). Biomimicry: A path to sustainable innovation. Design Issues, 31(3), 66-73.

[128] ILO (2019a). *Skills for a greener future: A global view based on 32 country* studies. Geneva: ILO Organization.

[129] ILO (2019b). *Estimating Green Jobs in Argentina 2019 Executive summary and conclusions.* Buenos Aires : International Labour Organization Argentina

[130] IRENA (2022). *Renewable Energy Market Analysis: Africa and its Regions*. Abu-Dhabi: IRENA.

[131] Saget et al., op. cit.

lost.[132] In that sense, labour market policies will be key to facilitating the transition of coal power plant workers (and most workers in so-called sunset industries) to other sectors and regions of the country. Avoiding the negative impacts of the transition and community resistance by providing alternatives that translate into better working conditions in the affected communities will be essential to ensure the inclusiveness of low carbon transitions across Latin America.

Financing, venture capital, and support for start-ups

Ramping up investment in low carbon sectors will require major policy reforms, not only to increase efficient public financing, but also to attract more private capital and support low carbon technology start-ups. Public policy support is critical to low carbon transitions and in the process toward a more sustainable social and economic model. In past successful national energy transitions, public financing was central, such as in Iceland (from fossil to geothermal energy), Norway (to hydroelectricity), France (from oil to nuclear), and the United States (from conventional to shale gas).[133] The key role of public financing lies in the fact that the availability of long term and nonrepayable R&D funding is essential to stimulate the early-stage development of low-carbon technologies, especially when profits from innovation can only be expected far into the future.[134] This is particularly relevant given the limitations of the banking and venture capital sectors to act as engines of innovation. The domestic private banking sector, especially in developing countries, tends to be risk-averse and often fails to provide the conditions that enable long term seed funding for innovations. Even in the context of venture capital, evidence suggests that venture capital investors are typically drawn to opportunities where the ideas can be commercialised, and their value realised, through an "exit" within a reasonably short period (usually 10 years).[135] As a result, the existence of a functional national development bank tasked with the mission of funding structural transformation towards higher value-added activities can help overcome some of these limitations, provide incentives and reduce the level of risks for long-term investments for innovation, notably through blended finance. In the context of climate change, National development banks (NDBs) are well placed to support green economic transformation through and the realignment of financial flows, through both direct financing and the mobilisation of private finance to fund the huge investment required for low carbon transitions.[136] Central banks are also in a powerful position to support the development of green finance models and enforce an adequate pricing of environmental and carbon risk by financial institutions, through their regulatory oversight over money, credit, and the financial system.[137]

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[132] Viteri Andrade, A. (2019). *Impacto económico y laboral del retiro y/o reconversión de unidades a carbón en Chile* (Estudio desarrollado para el Ministerio de Energía de Chile). Vogt-Schilb, A., Feng, K. (2019). *The labor impact of coal phase down scenarios in Chile.* Inter-American Development Bank; Saget et al., op. cit.

[133] Semieniuk, G., and M. Mazzucato. 2019. Financing green growth. In Handbook on Green Growth, ed. R. Fouquet. Cheltenham: Edward Elgar Publishing

[134] Anzolin and Lebdioui, op cit.; Mazzucato, M. (2016). From market fizing to market creating: A new framework for innovation policy. Industry and Innovation 23 (2): 140–156

[135] Lerner, J., & Nanda, R. (2020). Venture capital's role in financing innovation: What we know and how much we still need to learn. *Journal of Economic Perspectives*, *34*(3), 237-61.

[136] Griffith-Jones, S., Attridge, S., & Gouett, M. (2020). *Securing climate finance through national development banks*. ODI Report.

[137] Dikau, S., & Volz, U. (2018). Central banking, climate change and green finance.

In Latin America, the business case for green investments and ESG (Environment and Sustainability Governance) financial tools is already strong but more needs to be done to attract investment. A recent study by the Inter-American Development Bank revealed that Chile's pension and sovereign wealth funds might have realised higher returns than their extant portfolios had they adopted green investment strategies.[138] The idea that there is always a trade-off between sustainability and financial returns is therefore often a fallacy. Nevertheless, a lot more remains to be done to make investments in low carbon activities attractive to private capital. For instance, the low share of R&D investments across Latin America (relative to the rest of the world) is mostly financed by public funds, while private investment for R&D is much higher in OECD countries. Moving forward, the ability to attract venture capital into low carbon industrial ecosystems in Latin America, especially in start-ups, will be transformative. Without more innovation, decarbonisation and climate adaptation goals will be hard to reach, while nurturing clean technology start-ups to maturity can create local economic prosperity and represent a major market opportunity for Latin American countries.[139]

Clean technology venture capital investments and policy attention to start-ups have been on the rise around the world. Policy plays an essential role in clean technological innovation. In the past, this has taken place through funding R&D projects, providing tax breaks, and using market regulation. But governments are increasingly moving to support innovative start-ups directly with higher expectations that certain clean energy technologies (such as batteries, electrolysers, modular reactors, sensors, and solar panels) can be commercialised by private enterprise.[140] Start-up businesses are highly important to bring discoveries to the commercialisation phase but have a high risk associated with their operations, which is why venture capital and cooperation open a wide range of possibilities in the field of renewable energy technologies.[141] Effective public policies will be needed to overcome specific challenges faced by start-ups in the area of clean energy, which is a highly regulated, hardware-intensive sector that faces a fragmented and uncertain policy environment, as well as an investment community often unfamiliar with energy and sometimes poorly aligned with its funding needs.[142]

[138] Parrado et al. (2020) 'Invertir para crear mejores sociedades sin sacrificar los retornos'. *IDB,* accessible at: https://blogs.iadb.org/ideas-que-cuentan/es/invertir-para-crear-mejores-sociedades-sin-sacrificar-los-retornos/

[139] IEA (2022) *How Governments Support Clean Energy Start-ups*. Paris: IEA

[140] Ibid.

[141] IRENA (2015), op. cit.

[142] IEA (2022), op. cit.

Box 7. Start-up Chile

Chile's Production Development Corporation, CORFO, launched Start-Up Chile in 2010, at which time it became the first public business accelerator in the world, with a strong performance record. The purpose was to attract international entrepreneurs to connect with Chilean start-ups and raise the impact of the innovation ecosystem in Chile by providing a range of acceleration services (worth up to USD 300,000), such as grants financing, an advisory team that meets with recipients each month, workshops on various business services, pitch training, discounted external services, including cloud storage, software, and legal advice.

Since its launch, Chile has emerged as a start-up hub in Latin America for technologies with high potential for growth. Start-Up Chile has supported more than 2 200 new ventures in different sectors, supported more than 5 500 entrepreneurs, and provided more than USD 75 million from public resources.

While it is not energy-specific, it has run calls for energy-only start-ups and, for example, supported the Chilean start-up Endurance Electric, a provider of off-grid solar PV via a payment application, and Quempin, which operates in combustion efficiency for customers. [143] Nevertheless, despite those examples, the clean energy innovation ecosystem remains weak in Chile compared to its envisioned potential[144] and moving forward, a greater focus on innovation in key areas such as environment-friendly energy minerals extraction may be expected.

Circular Economy

The circular economy is an industrial economy approach to dematerialisation, which involves careful management of material flows and aims to decouple economic growth from the consumption of finite resources by reducing waste, in part by reinserting it into production processes.[145] Considerable net material cost savings exist if manufacturing sectors adopt circular economy business models.[146]

International trade can play a central role in advancing circular economy models, especially in terms of fostering economies of scale, leveraging foreign direct investment, and promoting innovation and technological development.[147] Various trade flows are directly linked to different circularity strategies, including the trade in waste, by-products, and scrap raw materials for refurbishment and remanufacturing, in second-hand goods and in services, as well as to produce biofertilisers to improve agricultural productivity, thereby helping diversify a country's export portfolio.[148] In contrast to linear production systems, where growing trade in non-valuable scrap and waste exacerbates environmental damage and leads to the dumping of textile and clothing, for

[143] Ibid.

[144] Ibid.

[145] Lütkenhorst, W., Altenburg, T., Pegels, A., & Vidican, G. (2014). Green industrial policy: Managing transformation under uncertainty. *Deutsches Institut für Entwicklungspolitik Discussion Paper*, *28*.

[146] Ellen MacArthur Foundation. (2015). Towards a Circular Economy: Business Rationale for an Accelerated Transition. Cowes: Ellen MacArthur Foundation.

[147] Albaladejo, M.; Mulder, N.; Mirazo, P.; and Jauregi, I. (2021) The Circular Economy: From waste to resource through international trade. *UNIDO Industrial Analytics Platform.* July.

[148] Ibid.

example, from developed to developing regions which often have weaker regulations (as illustrated by the recent case of dumping of used apparel in Chile[149]), circular production systems present an opportunity to use these materials and can be a valuable input for production processes in other countries.[150]

Countries in Latin America and the Caribbean could benefit from some of these trade opportunities, and several of them have already adopted national circular economy strategies.[151]

National Circular Economy Strategies in Latin America.

Approved	Under Preparation	Inception phase
		

Source: Mulder et al. op.cit

The circular economy also presents trade challenges for Latin American countries. Because the circular economy promotes the replacement of virgin raw materials with secondary raw materials, it could lead to a reduction in trade flows of minerals from the extractive sector, one of Latin America's main exports.[152] For example, if China were to develop a circular economy strategy for steel, this would affect Brazil as an exporter of iron ore, while circular economy measures in the OECD could lead to a decrease in international trade by as much as 50% for non-ferrous metals, 15% for primary iron and steel, and 10% for non-metallic minerals.[153][154] However, promoting greater circularity in the minerals and metals industries does not mean the disappearance of the mining activities in Latin America, but would instead complement them, as the path towards a low carbon economy is also associated with clean energies and critical minerals required to deploy them. [155]

Some industries and services also have greater potential for circularity than others. At the country level, advancing the circular economy agenda boosts sectors relevant to the industry, such as waste management, repair, maintenance, remanufacturing, and recycling.[156] Latin American countries must therefore be forward-looking and implement proactive policies that aim to leverage the circular economy to develop, increasing added value and productivity of local industries with the greatest potential for circularity and largest socio-economic spillovers to local communities.

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[149] Al Jazeera (2021). 'Chile's desert dumping ground for fast fashion leftovers. November 8, Accessible at: https://www.aljazeera.com/gallery/2021/11/8/chiles-desert-dumping-ground-for-fast-fashion-leftovers

[150] Ibid.

[151] Mulder, N.; Albaladejo, M; Mo, M.; Olmos, M.; Dante, P. and Mirazo, P. (2021) International Trade and the Circular Economy in Latin America and the Caribbean. Inclusive and Sustainable Industrial Development Working Paper Series 3/2021. ECLAC-UNIDO: Vienna.

[152] Ibid.

[153] Nechifor, V., Calzadilla, A., Bleischwitz, R., Winning, M., Tian, X., & Usubiaga, A. (2020). Steel in a circular economy: Global implications of a green shift in China. *World Development*, 127.

[154] Dellink, R. (2020). *The Consequences of a more resource efficient and circular economy for international trade patterns*. Paris : OECD.

[155] Mulder et al., op. cit.

[156] Albaladejo et al, op. cit.

Capacity building at the regional level

A range of policy actions can be taken at the regional and international level to promote inclusive, developmental, and sustainable low-carbon transitions in Latin America and the Caribbean.

Roadmap for regional supply chains and cross border biodiversity protection

A common guiding vision is a key to catalysing regional efforts towards developing trade around low carbon activities in the region.

Firstly, when it comes to biodiversity assets, it must be stressed that many environmental assets (such as the Amazon Forest) cut across borders in Latin America. Ensuring conservation and, by extension, the perennity of biodiversity-based economic activities, therefore, requires cross-border collaboration to avoid overexploitation of common goods. For instance, from the perspective of carbon trading in the region, mangroves are an exceptional resource for carbon storage (with the capacity to store 3-4x more carbon than most forests and provide other services such as shoreline stabilisation, biodiversity conservation, and disaster mitigation). However, mangrove in the region has declined by 20.22% between 2001 and 2018.148 The conservation of this ecosystem requires setting up regional frameworks for biodiversity protection.

From this perspective, the recent agreement between Colombia, Costa Rica, Ecuador, and Panama to create the Eastern Tropical Pacific Marine Corridor represents a laudable step forward. This initiative, launched in November 2021, will create the largest and most biologically rich marine biosphere reserve in the world, including a fishing-free corridor covering more than 500,000 km2 into one of the most important migratory routes in the world for sea turtles, whales, sharks, and manta rays.[157] The Eastern Tropical Pacific also has the highest indices of endemism in the world (due in part to the convergence of multiple ocean currents that have shaped the distinctive underwater seascape) and includes 160 identified endemic endangered species.[158] Besides its obvious ecological value, such a cross-border collaboration for biodiversity protection also has important implications for safeguarding the present and future possibilities to seek inspiration and knowledge from biodiversity to promote innovation in the region (see Section 4).

Secondly, cooperation to promote the regionalisation of supply chains related to clean energy and critical minerals also presents several benefits such as:

- Productivity gains through synergies and economies of scale for local suppliers and downstream processing activities.
- Resilience to external shocks and dependence on a single supplying country for low carbon technologies. For instance, the COVID-19 pandemic has caused considerable disruptions to the operations of many cross-border supply chains. [159] Such effects show that the long-term

[157] UNESCO (2021). 'Colombia, Costa Rica, Ecuador and Panama take the first step towards creating the largest transboundary marine biosphere reserve'. November 3rd, UNESCO Press release.

[158] Ibid.

[159] Seric, A., Görg, H., Mösle, S., & Windisch, M. (2020, April). Managing COVID-19: How the pandemic disrupts global value chains. In *World Economic Forum,* 27.

resilience of renewable energy deployment to exogeneous shocks will require further diversification and regionalisation of renewables supply chains.[160]

- Macroeconomic resilience in the context of climate change through opportunities for industrial diversification to overcome commodity dependence and the associated climatic vulnerabilities (see Section 2). The development of strong regional value chains around low carbon technologies, therefore, offers opportunities for jobs and value creation and a more resilient economy in the context of climate change.

To achieve these objectives, countries in the region must work together to assess the regional potential in critical mineral supply; share existing knowledge and available data on critical mineral deposits and their supply chains in each country, identify and fill existing knowledge gaps. The recent call for regional collaboration around critical minerals and the proposed adoption of a roadmap under the 2021 Mining Ministries of the Americas Conference (CAMMA) represents a promising way forward.

Regional information sharing to match supply and demand

Asymmetries and lack of information are key issues hindering regional integration and the development of regional supply chains around low carbon technologies. For instance, in the mining sector, information-sharing regarding procurement needs alongside clean energy supply chains, from mining to downstream industries, is essential to match suppliers and providers along critical minerals supply chains. Moving forward, a range of concrete steps can be taken at the regional level.

Because the transparent generation of quality information is essential to guide and attract investments, it is essential to gather more credible information to understand the critical minerals landscape through the completion of geological surveys. This can be achieved by supporting capacity-building programmes for the Association of Iberoamerican Geological and Mining Surveys (ASGMI) and national geological and mining surveys. For instance, resources, training programmes, and knowledge could be shared with geological and mining surveys in the region to strengthen the local capacity to conduct further exploration and mapping of critical minerals deposits in their jurisdictions.

Additionally, regional organisations could undertake a more systematic 'opportunity assessment' to identify regional investment priority projects based on existing strengths and limitations and regional supply chain development opportunities for specific technologies and critical minerals (e.g., wind turbines; graphene-based technology; e-mobility clusters, etc.). Similarly, a legal and regulatory assessment of existing trade agreements and how they might enable or prevent the agenda of regionalisation of supply chains will be key in guiding how regional cooperation can take shape around those issues.

[160] IRENA. (2020). *Post-COVID recovery: an agenda for resilience, development and equality*. Abu Dhabi: International Renewable Energy Agency.

Regional capacity building and coordination for green skills & low carbon R&D

Capacity-building around low carbon trading activities in Latin America and the Caribbean hinges on regional cooperation tools. Regional cooperation could take the shape of regionally recognised certification schemes for low carbon goods, which allows developing market opportunities and enhance trade. In the context of the growing need for sustainable extraction methods in the mining sector, as well the different degrees of maturity in mining production in the region, best practices could also be shared through regional 'clinics' / study tours (given the different degrees of progress in production across the region), and for local suppliers to engage with downstream actors and understand procurement needs.

Regional R&D initiatives also provide an opportunity to pool R&D resources to co-develop solutions for the region. Towards that end, regional innovation networks for specific technologies and challenges (such as high-altitude clean energy deployment or alternatives to water-intensive mining) could be set up to link research institutions across the Americas. Beyond academia, involving the private sector will also be of paramount importance in understanding industry needs. Therefore, drawing inspiration from the model of the European Battery Alliance, regional alliances for specific technologies and supply chains could be built, bringing together the private sector (mining companies; manufacturing firms), universities, and government institutions to develop regional capacity and identify challenges.

When it comes to seizing the trade opportunities that arise from the circular economy (see Section 5.1), regional cooperation will also be key. Synergies exist in terms of demand and supply of waste material and its re-use across the region. Implementing regional standards that can help foster trade in waste biomaterial and scrap materials, as well as repair and remanufacturing services, have the potential to help improve productivity and circularity in various sectors across the region.

Lastly, the regionalisation of carbon emissions trading systems would also have considerable effects on boosting biodiversity conservation and valuation across the continent, along with the adoption and harmonisation of environmental standards (in line with the Escazú Agreement) to support the management of protected areas that cut across borders. A continental deployment of payment for ecosystem services (PES), which are incentives offered to local populations in exchange for managing their land to provide ecological conservation services from which others benefit, would also be a positive move. Regional structures might also facilitate and help channel international financing for the support of environmental conservation in the region.

Towards a Latin American Green Deal?

Rationale

The multifaceted nature of the policies required to promote climate-resilient development models in Latin America, as well as the need for regional coordination of those policy tools and

strategies to achieve economies of scale and exploit existing synergies, heightens the relevance of a Green Deal.

The notion of a 'green new deal' is inspired by the massive mobilisation of resources led by President Franklin D. Roosevelt in the USA in the 1930s. The original New Deal entailed fiscal, monetary, and banking reforms, public works, other programmes, and new regulatory measures in response to the devastating financial crisis known as the Great Depression. Over 70 years later, in the aftermath of the 2009 financial crisis, the idea for another new deal that incorporates the climate change dimension emerged amid growing acknowledgement of the close interconnections between socio-economic and environmental dynamics. Despite the different circumstances, institutional contexts, and geographies in which Green Deal proposals have emerged, there are several characteristics that they have in common, including the adoption of unprecedented policy action and mobilisation of resources on a scale commensurate with the existential crisis.

To date, green deals have been proposed and discussed in various geographies and contexts, such as in the United States, the European Union, and South Korea, but have remained principally framed in the context of advanced economies, with discussions focusing on strategies to develop the productive and innovative capabilities of domestic firms in those countries. Their applicability and impact in developing countries have been neglected, even though these countries could stand to benefit tremendously.[161]

The concept of a green deal is of utmost importance in the Latin American context, where regional coordination is needed to foster synergies between various countries and subregions, expand economies of scale, and promote the development of resilient regional supply chains around low carbon technologies.[162] Each country in the region has different complementary strengths, from critical minerals abundance (e.g., Chile, Peru) to manufacturing capacity (e.g., Brazil, Costa Rica) and renewable energy potential (e.g., Mexico, Paraguay) as well as proximity to important trade routes (e.g., Panama), which can be fostered towards the development of an efficient regional industrial ecosystem around low carbon technologies, if appropriate resources and policy tools are used and coordinated. The idea of a Latin American green deal aligns with the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) advocacy to move the region towards a 'big push for sustainability' through a combination of economic, industrial, social, and environmental policies capable of driving a post-COVID-19 recovery and relaunching development in the region.[163] Discussing whether a green deal could be the way forward in Latin America is therefore justified and timely.

What is a green deal?

A Green New Deal is essentially a comprehensive policy package that aims to bring together the objectives of achieving climate goals (such as reduced GHG emissions); fostering economic development and job creation and guaranteeing social equity and welfare for society (see Figure 21).

[161] IRENA (2020). *Global renewables outlook: Energy transformation 2050*. Abu Dhabi: IRENA

[162] The relevance of a Green Deal in the Americas was recently highlighted in Aldana Cohen, D, & Riofrancos, T. eds. (2020) A green New Deal for the Americas. *NACLA Report on the Americas* (Summer), 52(2).

[163] ECLAC (2020). *Building a New Future: Transformative Recovery with Equality and Sustainability*. Santiago: United Nations

Figure 21: Diagram illustrating the broader objectives of a green new deal

Source: IRENA 2020

Different components of a Latin American Green Deal

A carefully designed Latin American Green Deal holds the potential to generate considerable positive impacts across a wide array of economic sectors. The most obvious impact would be in the energy sector, where a Green Deal could help support the large-scale regional deployment of clean, affordable, and reliable energy sources, as well as the coordination of the retraining and reintegration in the labour market of workers whose jobs in the fossil fuel sector are at risk because of energy transitions (IRENA, 2022). Additionally, opportunities also exist for supporting the agriculture sector and its climate resilience; industrial development around low carbon sectors and activities; inter- and intra-regional trade in clean energy technologies, services, and electricity; the environment-friendly extraction of critical minerals and their value addition; as well as biodiversity protection and ecosystem services (see Figure 22).

Figure 22. Examples of the multi-sectoral impact of a Latin American Green Deal

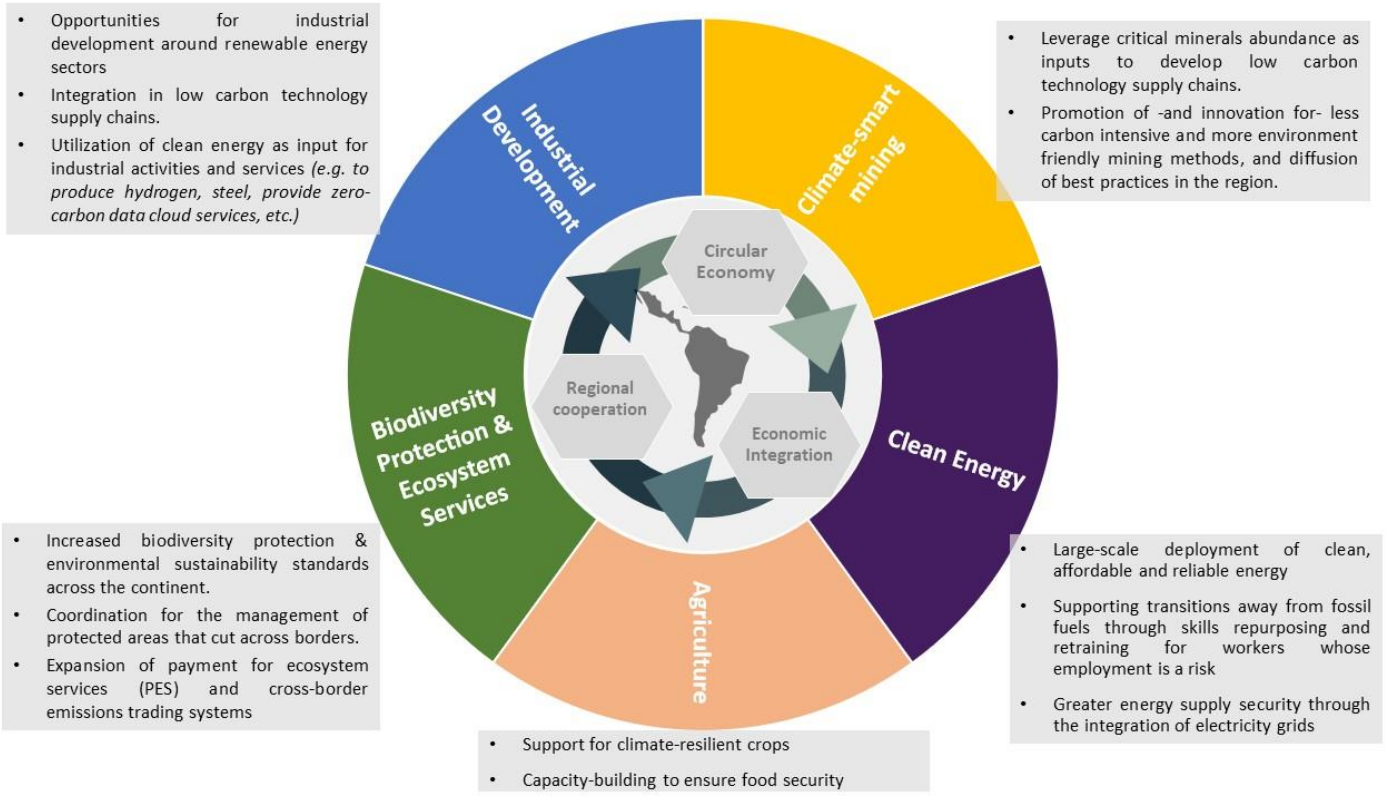

Figure 23. A Comprehensive Policy Coordination is required for a Latin American Green Deal.

Source: Author's

Box 8. Examples of measures that could be implemented as part of a Latin America Green Deal

- Coordinated deployment policies (such as feed-in-tariffs and auctions) to facilitate the integration of renewable energy into regional and subregional grids and transmission systems.
- Promotion of market integration by using regional quality certifications and standardization for low carbon technologies and associated services.
- Development of regional strategies for low carbon technologies besides national ones (e.g., a Regional Hydrogen Strategy).
- Expansion of regional training centres and knowledge exchange platforms
- Scale-up of technical and Vocational Education and Training related to renewables to reduce unemployment

Regional coordination and linkages amongst research centres dedicated to low carbon technologies.

However, a range of comprehensive policy tools is required to achieve a region-wide climate-smart structural transformation. Although the specifics may need to vary from country to country, a regional comprehensive policy package would need to include a broad mix of complementary policies such as the ones outlined earlier in Sections 5.1 and 5.2.

Challenges that lie ahead

Access to financing will be one of the key challenges in achieving a Latin American Green Deal. So far, investment towards green transformations has been suboptimal and insufficient to implement the 2030 Agenda for Sustainable Development and the Paris Agreement.[164] In the context of the post-COVID recovery, stimulus packages have also not benefited sustainable development due to the negligible share of green investment in total announced spending (0.4%).[165]

Based on the existing estimates of the total costs of climate adaptation and clean energy expansion, the funding required to finance a Latin American Green Deal is most likely going to exceed USD 1 trillion. Increased financing challenges are also brought about by reduced fiscal space for governments across the region in the aftermath of the COVID-19 crisis, as well as the Russia-Ukraine crisis causing a drop in demand for Latin American agriculture exports (such as cut flowers and bananas). However, the costs of financing a green deal needs to be measured against the economic losses generated by climate change on the continent, which has been estimated to be around

[164] ECLAC (2022). How to finance sustainable development. *Special Report COVID-19 No. 13.* Santiago: ECLAC.
[165] Ibid.

USD100 billion annually by 2050.[166] Furthermore, as discussed in Section 2, climate change is expected to lead to a considerable loss in GDP per capita across the region by the end of the century. Given the rising returns on investment in renewables and low carbon technologies, as well as the expected savings from regional cross-border trade electricity and low carbon goods, a massive mobilisation of local and international financing, along with support from international financial institutions, is justified.

Looking ahead, governments, the private sector, civil society, as well international development institutions will need to come together to overcome challenges and risks to financing and investing in a Latin American green deal. A mix of coordinated public investment, venture financing and blended finance will be essential moving forward. Ramping up the issuance of green sovereign bonds to finance national and cross-border projects could also be a way forward. The green bond market for Latin America and the Caribbean opened in 2014 has grown rapidly to be worth USD 21.6 billion between 2014 and 2020, with 67% of this amount issued by Chile and Brazil.[167] Expanding and replicating pioneering collaborative initiatives, such as the EcoEnterprises Fund, could help to channel financial flows to support green transformation across Latin America. This Latin America-focused venture fund, in which the Interamerican Development Bank (IDB) Group is a key investor, works with the private sector to invest in small businesses where long-term natural resource management is essential for their financial success. It has already mobilised USD 140 million for sustainable agriculture, agroforestry, and ecotourism.[168]

Overcoming political misalignments to achieve cooperation at the regional level constitutes a much more important obstacle to the design and implementation of a Latin America green deal. Such an ambitious programme would require considerable political vision and coordination at the regional level. Unfortunately, at the regional level political divisions exist and market integration has proved a difficult endeavour over the decades. These divisions range from ideological divergence to domestic polarisation, personal rivalries among the region's leaders, and positioning in terms of U.S.-Chinese geopolitical competition, and all are hampering regional governance and negatively impacting the prospects of cooperation.[169]

Yet cooperation persists in some formats even if more effort will be necessary going forward. Working together is necessary to achieving the socio-economic benefits of low carbon transitions. And fortunately, an ambitious regional agenda could capitalise on a wide range of existing institutions and initiatives at the regional and subregional levels. For instance, the Energy and Climate Partnership of the Americas, launched in 2009, aims to advance low carbon solutions in the region by providing a platform for governments to lead multi-country or bilateral initiatives on a voluntary basis. More recently, the Escazú Agreement adopted in 2018, which is the Regional Agreement on Access to Information, Public Participation, and Justice in Environmental Matters is the region's first treaty on environment issues and affirms the value of the regional dimension of multilateralism for sustainable development. By linking global and national frameworks, the

[166] Vergara et al., op. cit.

[167] Only 12 of the region's 33 countries had issued green bonds up to 2021 (ECLAC, 2022, op.cit.).

[168] Dasgupta, P. (2021). *The economics of biodiversity: the Dasgupta review*. HM Treasury.

[169] Merke et al. (2021). Reimagining Regional Governance in Latin America. Carnegie Endowment for International Peace. Accessible at https://carnegieendowment.org/2021/06/24/reimagining-regional-governance-in-latin-america-pub-84813.

agreement sets regional standards, fosters capacity building —particularly through South-South cooperation— lays the foundations of a supporting institutional architecture and offers tools for improved policy- and decision-making. Over the past two years, other movements have also sprung up to support regional cooperation around low carbon technologies, such as *Nuestra America Verde* and *Pacto Ecosocial del Sur.*

A Latin American Green deal could capitalise on existing cooperation mechanisms and bring together the key regional actors (such as the United Nations Economic Commission for Latin America and the Caribbean-ECLAC, the Inter-American Development Bank, and the Development Bank of Latin America-CAF), governments, multilateral institutions and the private sector to facilitate dialogue and consensus between different stakeholders, identify credible regional and subregional targets, identify and exploit synergies between different national and subregional energy transition strategies, and help overcome coordination issues. In addition, under the umbrella of a green deal, regional alliances can be created to coordinate the research, production, and deployment of specific low carbon technologies (similar to the model of the European Battery Alliance, which brings together EU national authorities, regions, industry research institutes and other stakeholders in the battery value chain). Existing efforts exist, but further support is needed. Finally, regional collaboration would also have to engage civil society as key stakeholders, as recently discussed by proponents of a Green New Deal in the Americas focusing on the role of social movements.[170]

[170] Aldana Cohen, D, & RioFrancos, T. eds. (2020) A green New Deal for the Americas. *NACLA Report on the Americas* (Summer). 54(2).

Concluding remarks

Climate change, and its mitigation, call for a major rethink of trade strategies and practices in the 21st century. Not responding to the demands of climate change is unlikely to help Latin American countries leap to the development frontier. Existing patterns of economic activity will change. Several oil producers in Latin America, for example, are facing already the effects of the global energy transitions; the demand for fossil fuels is expected to drop in the medium to long term. Given the region's dependence on petroleum exports, the consequences of decarbonisation will be considerable. The prediction, therefore, is that climate change will have an increasingly impact on trade and development across the globe, and in Latin America specifically because it is likely to seriously jeopardise economic productivity, human livelihoods, and food security, among many issues.

On the upside, the global push towards sustainability can bring about considerable opportunities for trade and investment in Latin America with the right vision and policy tools. For Latin American countries to seize "Green Windows of Opportunities," governments and the business sector will need to undertake adequate reforms to support regional renewable energy supply chains, green hydrogen production, circular economy initiatives, biodiversity-based innovation models, and more sustainable methods for extracting critical minerals that are key inputs for low carbon technologies.

The good news is that across the region several countries are showing increasing high climate ambitions, impressive successes in terms of clean energy deployment, great ambitions for low carbon services, and pioneering biodiversity-based development initiatives. However, a lot more remains to be done to reap the full potential that clean transitions can provide in Latin America and to compensate for the expected income and job losses in the fossil fuel sector. A lot more remains to be done to bridge renewable energy expansion, biodiversity conservation, and critical minerals exploitation with high value-added trade and industrial development in the region. Multi-layered productive transformations are needed across numerous interrelated sectors to achieve such an objective. The promotion of climate-smart mining will be required to support a less carbon-intensive exploitation of critical minerals that will fuel clean energy deployment in the region, while potentially providing opportunities to develop resilient regional supply chains around renewable energy technologies. Latin American countries can take advantage of cheap and clean electricity sources not only to decarbonize electricity generation but also as input to develop competitive high value-added low carbon services.

Similarly, when it comes to the region's unique natural ecosystems and biodiversity, building on existing efforts to capture the trade value of ecosystem services represents a key agenda moving forward. Beyond ecotourism, carbon emissions trading systems need to cut across country and continental boundaries for carbon markets to be leveraged as a trade tool. In parallel, bio-innovation provides another promising pathway for capitalising on the trade value of biodiversity in Latin America, constituting a very dynamic and emerging area for future investments, start-ups, and venture capital.

A wide range of coordinated policy tools is needed both at the national and regional level to foster the development of competitive low carbon services and high-value-added ecosystem services biodiversity-based activities. Regional cooperation will also be essential to promote regional supply chains around low carbon technologies, from critical mineral extraction to the value addition of renewable energies and low carbon services, which would allow considerable productivity gains through economies of scale for local suppliers and downstream processing activities, as well as offer opportunities for diversification, jobs creation, and industrial development.

In that sense, a Latin American Green Deal could provide a way forward as a platform for the regional coordination needed to foster synergies between countries and subregions. Each country has different complementary strengths, which can be leveraged through the use and coordination of appropriate resources and policy tools. Nevertheless, several obstacles remain to achieve the political coordination required at the regional level for such a programme. Alternatively, building upon existing regional initiatives and fostering bilateral and multilateral agreements to foster regional supply chains around low carbon goods and services could also offer a way forward.

Considering the significant opportunities and challenges for the future of Latin American trade, it is clear that governments in the region, along with their international trade and investment partners, need to step up ambitions and take bolder steps towards greener development models that are based on the development of low carbon industries.

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