### Seizing Brazil's Climate Potential



Brazil Climate Summit.



### BRAZIL CLIMATE REPORT 2024

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#### About this report

Objective

This report is a BCG vision for Brazilian and foreign leaders, decision-makers and the broader civil society to help catalyze efforts, tackle challenges & maximize value from opportunities intrinsic to Brazil during the transition of World's economy to Net-Zero.

Audience

This report was built for all those willing to drive actions against Climate Change (e.g., investors, board members, executives, entrepreneurs, academia, etc.) focused on leveraging Brazil's green agenda and potential.

Data

This document is a compilation of public information and BCG expertise, carefully selected, to bring numbers and facts to Climate discussions and decision-making. Its analyses are subject to rapidly evolving technologies and business models and should be revisited and updated accordingly.

Special thanks BCG is thankful to the support received by the entire organizing team of Brazil Climate Summit, especially to all Brazilian students at Columbia University who contributed to accelerating the path to Net-Zero. (www.brazilclimatesummit.com)



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#### Executive summary

# Brazil is uniquely positioned to offer effective climate solutions at scale for the world

Z

Introduction

Decarbonize the world is crucial, demanding immediate action

- Key to reduce climate change impacts and avoid up to ~30% in GDP loss
- Advances are noticeable, yet
   <35% of emissions are covered by commitments by 2050
- A sustainable future demands action along 4 pillars – this report focuses on Mitigation and Adaptation & Resilience





BR is well-positioned to be a Net-Zero catalyst and attract \$2.6-3T of investments by 2050

- Natural resources, high productivity & green power matrix favor position
- Potential to lead in RegAg<sup>1</sup>, NBS<sup>2</sup>, Green H<sub>2</sub>, Biofuels & Industry
- Leading to up to 1.7x in investments by 2030
- Enabled by low emission solutions on 4 sectors: Nature, Sustainable Agri, Renewable Energy, Green Industry

Adaptation & Resilience

Effects of climate change require A&R actions from private & public sector in BR

- +50% of disasters globally vs.
   90's, and +BRL 420B damage in Brazil in 10 years
- 7 key areas to invest, with up to 15x benefit-to-cost ratio
- **+150B p.a**. investment gap, specially from private sector
- Public & private sectors to combine efforts with the right funding to advance projects

Biofuels' Case Study

#### Brazil has an opportunity to transform the transport sector with biofuels

- BR already a top global producer, #2 in ethanol & #4 in biodiesel
- ~100 Mha of degraded area available for sustainable expansion and high productivity
- Reaching full potential, Brazil could supply 100% of its transport sector with Biofuels...
- ... reducing sector emissions by 55%+ and unlocking up to \$200B in investments

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# Decarbonizing world's economy is urgent and crucial to avoid major disasters and loss of wealth in this century



1. Based on submitted NDCs. 2. Modelling conducted from 2020 baseline using projected 2020 emissions. Note: Emission gap for 2°C pathway estimated to be ~14 GtCO2e (UNEP Emissions Gap Report 2023). Temperature increase refers to global warming by 2100; GDP loss (due to Global Warming impact) is per capita, vs. no additional global warming Source: ClimateReanalyzer.org; Climate Change Institute; University of Maine; Climate Action Tracker; UN Intergovernmental Panel on Climate Change (IPCC); BCG analysis



Selected examples

## Advances in the global agenda over the last two years provide inspiration...





## ... yet efforts to mitigate & adapt to climate change are falling short of what is required





### The path to sustainability relies on 4 pillars - mitigation, adaptation & resilience are the focus of the report

#### Mitigation

Limitation of the effects of climate change by reducing emissions or removing greenhouse gases from the atmosphere

#### Adaptation & Resilience

Adjustment for environmental changes from climate change to mitigate harm or exploit opportunities and quickly recover from climate events efficiently



#### Loss & Damage

Answer to residual impacts of insufficient mitigation and adaptation from extreme or slow-onset events

Focus of this report



Climate Finance

Investments in mitigation, adaptation and resilience as well as covering the costs of loss and damage



### The path to sustainability relies on 4 pillars - mitigation, adaptation & resilience are the focus of the report

#### Mitigation

Limitation of the effects of climate change by reducing emissions or removing greenhouse gases from the atmosphere



Brazil can become a hub of lowemissions solutions, leveraging its capabilities and natural resources

#### Adaptation & Resilience

Adjustment for environmental changes from climate change to mitigate harm or exploit opportunities and quickly recover from climate events efficiently

#### Loss & Damage

Answer to residual impacts of insufficient mitigation and adaptation from extreme or slow-onset events

**Climate Finance** 

Investments in mitigation, adaptation and resilience as well as covering the costs of loss and damage

#### Transition to NZ creates opportunities of +\$ 100T in investments by 2050

#### Scale of change

in numbers



### \$100-150T

Total climate-aligned accumulated investments for the next 3 decades





Avg. annual investments in 2020-50 (peak of \$10T per year around 2030)



#### Global Climate Financing Need (US\$ T)



• Investment is expected to be highly frontloaded until 2035

#### Non exhaustive

Commercially viable

Investments pursue Climate Solutions at scale (some of which are already viable)

Renewable energy
 Biomass & biofuels
 Sustainable agriculture
 NBS (carbon offset)
 Electrification & batteries
 Green Hydrogen (enabling low-carbon steel/cement)



## Brazil is positioned as the 5<sup>th</sup> in rank of emissions, being a fundamental part to achieve global NZ goals...

1.9

Indonesia

1.6

Australia

\*\*

1.4

Japan

1.2

Canada

\*

1.0

Rep. Congo

Top 10 countries – Greenhouse gas (GHG) emissions Per country, 2019, in Gt CO<sub>2</sub>e





## ... while local emissions & challenges highly differ from those in rest of the world

### Total GHG emissions 2019, share of total (in Gt $CO_2e$ )





100%

#### Brazil's AFOLU remained steady from 2019 to 2022 both for gross and net emissions





Note: Net emissions discount the carbon removed from the atmosphere (e.g., by forests, soil) from gross emissions Source: SEEG







# Brazil is still far from its desired targets for NZ & deforestation, and is currently reviewing NDCs to meet Paris Agreement



Brazilian government is revising its Nationally Determined Contribution (NDC), to be announced by 2025, following the Paris Agreement's 1.5 °C guideline

Note: Following commitments of Out/2023 disclosed by Brazilian government Source: UNFCCC; Brazilian government; INPE DETER; Ibama; BCG analysis



#### Brazil is distinctively positioned to offer climate solutions...



# ...creating the opportunity to become a global hub of climate solutions

Protagonist in Wind and Solar:

7-10 GW installed yearly, with 📌

\$15B+/yr in investments<sup>2</sup>

LCOE: \$33/MWh pre-incentives;

**#1 CO**<sub>2</sub>**-offset supplier:** mitigate up to 1 Gt CO<sub>2</sub>e p.a. by 2030 through NBS, with **+\$70B** of revenue pool<sup>1</sup>

Zero illegal deforestation through command and control (tech + law enforcement) & effective fighting of natural fires

Increased Sustainability in wastewater treatment coverage and clean water supply

**#1 country in Regenerative Agric. at scale** (up to 100 Mn hectares of Crop-Livestock-Forest Integration or no-till farming, +70% of cattle yields with pastureland recovery)

Expansion of efficient long-haul modals (waterway, rail) to reduce emission footprint

Green H<sub>2</sub> : Competitive renewable grid and local demand positioning to capture **10-15%** of global exports +2030<sup>3</sup>

> Leadership in biomass & land for sustainable expansion could allow replacement of fossil fuels with biofuels in transport sector

Worldwide hub for lowcarbon industrial products and key supplier of critical minerals benefiting from clean energy, competitive Green H<sub>2</sub>, natural resources and NBS

1. Assume potential of NBS in a price-competitive scenario with carbon price at \$70/ton CO<sub>2</sub> 2. Average Levelized Cost of Energy for wind & Solar plants, considering experts inputs, capacity expansion as disclosed by ONS in 2023, and average renewable energy investments in Brazil between 2015-2022 as reported by UNCTAD in 2023 3. BCG estimates



# Brazil's climate hub potential goes beyond Net Zero, unlocking up to \$3T in investments

Investments expected to sum \$2.6-3T until 2050 ...





1. Agriculture, forestry & other land use. 2. Refers to additional investments in Brazil to support the World in the transition to Net-Zero (e.g., energy investments to develop low-carbon solutions, export green H<sub>2</sub>, carbon credit supply from NBS) Source: Oxford Economics; BCG Report – Climate Finance Markets & The Real Economy; FMI; LCA; IBGE; CEIC; BCG analysis



## Brazil can become a Climate Hub by leveraging distinctive comparative advantages

#### Nature

BR is #1 country in reforestation globally, holding up to 1.0 Gt CO<sub>2</sub>e per year of NBS mitigation potential

### Sustainable Agriculture

2

#1-2 exporter of most
commodities (soy, orange
juice, sugar, meat, corn),
BR can continue to scale-up
while reducing emissions

### Renewable Energy

3

88% of renewable power (vs. 29% world); Availability & low costs on wind, solar and biomass enables low emission footprint

### Green industrial products

Natural resources, clean energy and biodiversity allows supply of low-carbon goods addressing regulatory requirements

Reforestation Avoided & Restoration conve





ji



WD A







Low-carbon basic items (e.g., Steel, Cement...) Green BR Industrial products



## Brazil can become a Climate Hub by leveraging distinctive comparative advantages





## Brazil is the country with the highest maximum theoretical potential for Nature Base Solutions



1. Annual cost below 100 USD per tCO<sub>2</sub>e mitigated or captured - Griscom et al (2020) and Roe et al (2021) reviewed the cost-effective potential to 1.35 and 1.65 GtCO2e/year Source: Griscom et al; Roe et al; BCG analysis



+ \$ 140M investments Reflecting momentum of major restoration and reforestation projects commitments





## Brazil can become a Climate Hub by leveraging distinctive comparative advantages

Nature

#### Sustainable Agriculture

2

#1-2 exporter of most
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BR can continue to scale-up
while reducing emissions

### Renewable Energy

### Green industrial products

Cement...)

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Green BR

products

 Image: state stat

Reforestation & Restoration

Avoided forest conversion



Brazil has the resources and comparative advantages to grow sustainable food at scale



Sustainable resources

productivity

**Advanced** 

techniques

High

•

exporter of many foods and in CO<sub>2</sub>seq potential

**89Mha** of pastureland suitable for sustainable intensification

**3x** is the Brazilian crop yield ratio *vs.* world average

harvests on average per year (up to 3 in some regions)

**1.7**k

**AgTechs** in Brazil, 50% increase in the last 3 years

in **no-till farming** & pioneer in regenerative practices

Deep-dive available in Brazil Climate Report Europe 2024

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#### Brazil has a mature and robust agriculture ecosystem



Source: IPEA; EMBRAPA; BCG analysis



## The recovery of pasturelands represents a path to sustainably meet future food demand



Below optimal productivity capacity Know-how and capital-intensity are the main difficulties faced in Brazil, demanding powerful investments mechanisms, such as blended finance & private investments

Deep-dive available in Brazil Climate Report Europe 2024

Note: Degraded pastureland have a stocking rate of 1 cattle head/ha

Source: Plano ABC+; EMBRAPA; Climate TRACE; Experts interview; Finance for a Forest-Positive Future - IFACC (2022); BCG Analysis

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## Brazil can become a Climate Hub by leveraging distinctive comparative advantages

Nature

### Sustainable Agriculture

### Renewable Energy

3

88% of renewable power (vs. 29% world); Availability & low costs on wind, solar and biomass enables low emission footprint

### Green industrial products

Reforestation & Restoration

Avoided forest conversion

Regenerative Agriculture

Biological Low-carbon Fertilizers protein Biomass R & Biofuels

Renewable Energy

**- 7** 

Green H<sub>2</sub>

H

Critical Minerals resources

Low-carbor basic items (e.g., Steel, Cement...) Green BR Industrial products

Non-exhaustive

## Recent investments in Renewable Energy in Brazil include a wide variety of subsectors



Raizen invested ~\$480 M to build two new 2G ethanol plants and expects to invest a total of \$4.8B in 20 new plants until 2030 Unilever invested ~\$10 M in the construction of a biomass power plant to supply its unit in São Paulo reduce emissions by 37,000 tCO2e/year The ethanol & sugar producer **Atvos** plans to invest +\$70 M in a **biomethane plant** in Mato Grosso do Sul, with inputs from the sugarcane chain

Eletrobrás invested +\$400 M in its Wind Plant, with an installed capacity of 29.4 MW

**Casa dos Ventos** announced \$2.4 B into renewables and plans to add 1GW solar generation to its wind assets

#### 2023



Federal government announced the investment of +\$40 B in biofuels, destinated to: SAF, HVO, ethanol, biodiesel & carbon capture & storage



EU pledges to invest ~\$2 B to develop green hydrogen in Brazil, boosting transition to clean energy



2024

Mubadala Capital, fund that controls Atvos & Acelen, announced its intention to invest a total of + \$13.5 B in biofuels in BR



BYD and GWM announced the first Electric and Hybrid Vehicles plants in Brazil with a total investment over \$2.5 B

EVs





# Brazil stands as a top producer of ethanol and biodiesel, and is unveiling its potential in HVO, SAF and RNG markets...



1. CONAB data from 4th sugarcane report of 2022/2023 crop 2. ANP/ABIOVE 3. Estimated considering emissions if energy demand of ethanol production was replaced by gasoline & biodiesel production was replaced by diesel Source: CONAB; ANP/ABIOVE; ANP – Biomethane panel; SEEG 2022; Press releases; BCG Analysis

#### ...with potential to transform the transport sector by 2050

If Brazil uses its full feedstock potential, enhances yield & restores degraded land by 2050, it could:

+100% Supply of the energy demand



Reduce emissions in the transport sector

Supply all Brazil's

transport sector

-55% of GHG emissions Reaching *Climate positive* with BECCS



Create significant market opportunities \$100-200 B Investments in additional capacity

.... While still addressing food security & land use concerns

## Moreover, Brazil also has outstanding potential for wind and solar, with multiple investments in recent years...



1. 50% destined to Gerdau and the remaining to the ACL Note: The years presented are the duration of the contract between the company and the renewable energy supplier Source: ANEEL; CCEE; DCIDE; BCG Analysis

## ...And a robust pipeline of solar and wind projects by 2032 to be materialized with demand

#### Solar & wind supply expansion ANEEL supervised projects<sup>1</sup>, GW



Brazil experienced a significant growth of +9GW in solar & wind capacity in 2023

...with a robust pipeline planned for 2032, however, only profitable opportunities will be realized...

...new & growing markets can enable this expansion, e.g.:

- Development of Brazil's Green H<sub>2</sub> hubs
- Expansion of Data Center power demand

1. Projects supervised by ANEEL until July of 2024 according to RALIE 2. ANEEL's feasibility parameter indicates expectation of the enterprise to be completed or not, classified as high (current Environmental Installation License and ongoing civil works – without impediments to implementation), medium (uninitiated works or with unfinalized Environmental Licensing – without impediments to deployment) and low (suspension of Environmental Licensing or Declaration of Environmental Unviability, revocation process under analysis, judicial demands – no expectations of implementation Source: ANEEL; BCG analysis





## Competitive wind and solar generation is a favorable condition for the development of several green H2 projects

	Maranhão	Eletrobras Suzano		Non-ex	khaustive	
	Porto de Pecém, CE	International Contractions Hydrogen 🔬 of edp 🚎 🖗 enegix 🚎	Qair 🚆		Eletrobras	
	Porto Luis Correia, Pl	Eletrobras (	USD <sup>in</sup>	in MOUs <sup>2</sup> to pro H2, for local cor	MOUs² <b>to produce green</b> 2, for local consumption	
	Rio Grande do Norte		+30B	and exporting		
	Porto de Suape, PE		however, projects still in <i>early-stage, without concre</i> <i>development yet</i>		ojects still without concrete	
	Camaçari, BA					
	TBC1	VALE <sup>B</sup> H2 <b>green steel</b>		Energy	Solar Wind Onshore Wind Offshore	
	Porto do Açu, RJ			source:		
	São Paulo	🕐 raízen 🕀 Hytron 🗬		End	(1) H <sub>2</sub>	
2	Porto de Rio Grande, RS			product:	📸 Ammonia	

1. The number of industrial hubs that will be built, their location and production capacity will be defined following feasibility studies to be developed jointly by Vale and H<sub>2</sub> Green Steel; 2. Memorandums of Understanding Source: Press releases; BCG analysis



# GenAI expansion can boost demand for Data Centers, with potential to represent 16%+ of US electricity demand



1. Estimated consumption for early applications of ChatGPT, traditional google search requires 0.3 Wh, ChatGPT query requires 2.9 Wh 2. GenAI power demand based on a high case of hardware supply constraint market 3. US estimated power demand based on expected utilization rates for each DC segment by year (ranging from ~85-87% in 2024 to 85-90% in 2030); Low case defined as a DC infrastructure constrained case based on current and planned facilities; High case based on hardware constrained environments based on bottom-up GPU supply; Values rounded Source: NERC; Expert interviews; MLPerf; Nvidia quarterly earnings; press releases; product datasheets: EPRI; IEA; BCG analysis and case experience





# Brazil clean energy availability could create opportunities for local Data Center market expansion



1. Illustrative exercise for Brazilian market considering capture of 5-10% of upper US Datacenter market growth by 2030 2. Estimated Capex of BRL 25 B/GW, considering average investments of recent datacenters in Brazil over 10 MW 3. Estimated Capex of BRL 3.2 B/GW for solar plants and BRL 6.2 B/GW for wind plants in a 50% mix of each, with a capacity factor of 25% & 50% for solar and wind plants, respectively 4. LLM stands for Large Language Models Source: JLL; ABDI study; BCG analysis


## Brazil can become a Climate Hub by leveraging distinctive comparative advantages

Nature

## Sustainable Agriculture

## Renewable Energy

### Green industrial products

Natural resources, clean energy and biodiversity allows supply of low-carbon goods addressing regulatory requirements

Green BR

Industrial

products





### Investors and Lenders are increasingly seeking companies committed to net-zero...

Managers pursuing more sustainable investment strategies...



"In the long run, we will see evidence that sustainable investments will be at least BlackRock. equivalent to core investments. Personally, I believe they will be bigger". (Larry Fink, CEO of BlackRock, 2018)

... and commercial banks seeking to mitigate climate change

**Morgan Stanley ABN**·AMRO Itaú

120 financial institutions have committed to measuring and reporting GHG emissions associated with their credit and investment portfolios (39% of global banking assets)

PRI **UN-Convened** Net-Zero Asset Owner Alliance

Group of 30 of the world's largest managers (\$ 5 T AuM<sup>1</sup>) have pledged to reduce 30% of emissions from their portfolios by 2025

2020 - 2025

Citi Group alone allocated **\$250B** to invest in low-carbon transition between

38

1. Assets under Management

Source: Global Carbon Accounting Partnership (PCAF); Net Zero Banking Alliance; Press Search; BCG Analysis



### ... while main users of industrial inputs are choosing lowemitting suppliers to meet their reduction emission targets Selected examples

#### Automotive

- Target of reducing emissions by 40% by 2030 across the production chain
- Designing strict sourcing criteria and establishing long-term contracts to encourage investment
- Target of reducing emissions by 40% by 2030 across the production chain
- Investment plan of ~\$14B by 2025
- CO<sub>2</sub> emissions will be key criteria for closing contracts with suppliers



• Goal to have the entire CO<sub>2</sub>-neutral fleet in 2039



### Construction

- 2030 targets set according to the UN SDGs, without numerical emission reduction targets
- Partnership with Ekos<sup>1</sup> Institute to offer discount • to suppliers who want to offset emissions (scope 3 represents 95% of emissions)
- Announcement of the company's first GHG emissions inventory, which will include scopes 1, 2 and 3
- Targets will be announced after inventory



MRV

CYRELA

Target of 47% reduction of scope 3 emissions by 2030

1. NGO created to preserve biodiversity and promote sustainability projects Source: Sustainability reports; Press Search; Interviews with Experts; BCG Analysis

All I



# Critical minerals are fundamental to achieve NZ with energy transition, with Brazil's potential assessed by 3 main criteria





<u>للم</u>

Grid network

Batteries

ሉ Wind Turbines



### Brazil is a strong candidate to supply Nickel, Graphite, Lithium and Rare Earths with relevant reserves...



1. Forecasted demand for 2040 is based on the IEA Global Critical Minerals Outlook 2024, following respectively the STEPS and the Net Zero scenarios 2. Demand and production figures pertain solely to magnet rare earths (e.g., neodymium, praseodymium, dysprosium, terbium), while reserves are represented in terms of total rare earths, measured as rare earth oxide equivalent (REO) 3.Production and reserves for all minerals (excluding rare earths) are expressed in million tons of raw materials as of 2023 4. Estimated revenue potential, based on STEPS and NZ scenarios, assumes Brazil's fair share ranging from 2% to 20%, guided by its share of current reserves. Source: USGS Mineral Commodity Summaries 2024; IEA; Igarapé Institute 2023; BCG Analysis



## ... and comparative advantages addressing key concerns related to the supply of critical minerals in the future

#### Favorable Geopolitical Environment

17

Brazil stands out as a potential key player with a favorable geopolitical position, assuring reliable supply for high incentives demand e.g., IRA related Low Production Carbon Footprint

<u>i</u>

Brazil's 88% renewable power & 22% renewable-powered transportation<sup>1</sup> enables a low-carbon mining industry





#### Less Exposure to Water Stress

Brazil's lower water stress level offers a sustainable solution for future production of Lithium, which is vulnerable to water stress

Water Risk Score of major lithium producers<sup>2</sup>





## Sustainable resources enable Brazil to become a world provider of low emission industrial products



1. Estimated based on Vale, whose estimated market share is ~55% (in revenue, 2020) 2. On scopes 1 and 2, scope 3 not included. Source: SNIC; CNI; Citi GPS; Raizen Ethanol Sustainability report; Expert interviews; Press releases; BCG analysis



## Overall, Brazil has room for steering investments towards the green economy

Brazil can significantly increase the Private sector share of green investment

Private sector participation in green transformation projects (%)<sup>1</sup>



Green bonds are an example of financial solution that can be further explored

Green bond market as a % of total investment<sup>2</sup>



1. Persaud (2023); 2. Average of cumulative green bond market from 2014 to 2023 normalized by Gross fixed capital formation per country (2022) Source: Brazilian Ministry of Finance; Climate Bonds Initiative report 2023; World Bank; BCG analysis © 2024 by



### Looking ahead, policies and legal framework evolving towards a sustainability pathway for private sector investments

Congress is advancing climate bills...



Hydrogen Law approved by the Chamber of Deputies to regulate the production and use of low-carbon and renewable hydrogen

Dec/23 Carbon Mai Chamber of

Carbon Market Bill approved by the Chamber of Deputies to establish Brazil's carbon market

Bill to regulate offshore wind energy production approved by the Chamber of Deputies



Feb/24

Fuel of the Future approved by the Chamber of Deputies to increase the volume of biofuels in transportation matrix



lun/23

Dec/23

Ecological Transition Plan launched to guide sustainable development through mitigation strategies

... while Government initiatives show results...

Agricultural Plan 2023/2024 to support sustainable farming practices and tech advancements in Agri

Degraded Pasture Recovery Plan initiated to restore degraded pastures into Sust Agri and forestry systems

Feb/24 Eco Invest Brazil program to mitigate green investments exposure to exchange rate ("hedge cambial").

62% less deforestation in the Amazon<sup>1</sup> from intensified monitoring & control

\$1.2B pledged to the Amazon Fund, with extra \$150M raised after resuming activities 3<sup>rd</sup> largest increase in installed wind power capacity
6<sup>th</sup> Country to invest in energy transition (\$35B)
0f BR companies with Net Zero commitments (in 2022)

... and private sector emphasizes commitments

Voltalia signs pre-contract for the production of green hydrogen in Ceará

the AstraZeneca announces investment of R\$350 million in the restoration of the Atlantic Forest

Suzano, Marfrig, Rabobank and Vale invest R\$80 million in forest preservation company

Yara announces investment of R\$90 million in factory in Sumaré (SP) notable for the second productor of amonia from biomethane Notable for the second productor of amonia from biomethane

Raízen announces investment of R\$1.3 billion to produce E2G in Caarapó (MS)

1. Considering total area, not only protected areas, 2023 vs 2022 Note: VCM stands for voluntary carbon market)

Source: Imazon; ANEEL; ONS; (all 2023 data); Senado; CNN Brasil; Notícias Agrícolas; APAS; InvestNews; Exame; ABEEólica; BloombergNEF; Climate Focus



### The path to sustainability relies on 4 pillars - mitigation, adaptation & resilience are the focus of the report

### Mitigation

Limitation of the effects of climate change by reducing emissions or removing greenhouse gases from the atmosphere

### Adaptation & Resilience

Adjustment for environmental changes from climate change to mitigate harm or exploit opportunities and quickly recover from climate events efficiently



Increasing natural disasters demand 📀 action from public & private players in Brazil to address climate change

### Loss & Damage

Answer to residual impacts of insufficient mitigation and adaptation from extreme or slow-onset events

### **Climate Finance**

Investments in mitigation, adaptation and resilience as well as covering the costs of loss and damage



## Adaptation & Resilience is an imperative with climate change, requiring combined action of public & private sectors



1. NAP stands for National Adaptation Plans

Source: EM-DAT: The Emergency Events Database; MMA; CPI Global Landscape of Climate Finance 2023; UNEP Adaptation Gap report 2023; Adaptation Agenda 2023 Implementation Report; CDP 2023 Disclosure data sheet



#### 3 Adaptation & Resilience

# Impacts of climate change are worsening, becoming increasingly near-term and costly



1. Climate and weather-related disasters (i.e., excludes earthquakes and volcanic activity) Source: Our World in Data; EM-DAT: The Emergency Events Database; Desk Research

# Cities are particularly susceptible to climate hazards and associated socio-economic risks

Today, most of the world's population live in cities

>50% of world population

lived in cities by 2023

Expected to reach  $\sim 70\%$  by 2050

Creating a high socioeconomic ROI with spill-over effects as they are centers of social, economic and government activities



The highest concentration of economic activity including jobs and GDP contribution, generating over 80% GDP globally



Hubs for basic social services (e.g., hospitals, schools), recreational, religious, and cultural activities



Home to government activities (e.g., ministries, parliaments & the judiciary) and operate as the country's administrative center



# Climate impact is increasingly alarming in Brazil, with severe damage throughout the country

### Impacts already felt in recent years

+65%

areas susceptible to droughts in northeast in 2010-2019 compared to 1950-1959

4 M+

People needed to leave their houses due to climate change disasters from 2013-2022 in Brazil<sup>1</sup>

BRL 420B+

Of estimated cost damage from climate change from 2014-2023<sup>2</sup>

### Flood example | Rio Grande do Sul



**450+** cities affected, 78 decreed calamity<sup>2</sup>



**180+** people lost their lives<sup>3</sup>



**2.4 M** people affected, ~22% state population<sup>4</sup>



**>RS 97 B** in estimated losses for Brazilian economy<sup>5</sup>

1. CNM report of 2023 2. MMA 3. As of Jun/2024, according to state civil defense 4. As of May/2024, according to state government 5. Estimated impact as of Jun/2024 Source: IPCC AR6 Chapter 12; CNM 2023; MMA; Press releases; State civil reports; CNC report; BCG Analysis

# A&R actions can create a high socio-economic return for private players & society



Up to

Net benefit-to-cost ratio, representing high potential returns of A&R in global scale

4-9x

<sup>Up to</sup>

Savings annually from investing \$800M in early warning systems in developing countries

1. Considers returns from potential investments in 5 business cases: Strengthening early warning systems, Making new infrastructure resilient, Improving dryland agriculture crop production, Protecting mangroves, Making water resources management more resilient, including benefits from avoided losses, economic, social & environment benefits Source: Global Commission on Adaptation 2020; BCG Analysis



## Investments can unlock sizeable benefits by avoiding losses, creating economic, social & environment opportunities

#### Benefits were estimated for 5 investments cases (10 year benefit over a 5 year investment period)



#### Covering benefits in 3 areas

#### Avoid loss

E.g., warning systems can save lives and reduce losses, a 24 hr warning could cut disaster cost by 30%+, with estimates of up to \$16B saved from \$800M invested



#### Economic benefits

E.g., reducing flood risks in cities makes investments that would otherwise be too vulnerable possible, as the Canary Wharf development on the back of Thames barrier



Social & environment benefits

E.g., Mangrove protection enhance trade & logistics, ensuring livelihood protection and avoids losses from coastal flooding

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Note: The net benefits illustrate the approximate global net benefits to be gained by 2030 from an illustrative investment of \$1.8 trillion in five areas, rounded. Actual returns depend on many factors, such as economic growth and demand, policy context, institutional capacities, and condition of assets. Due to data and methodological limitations, this graph does not imply full comparability of investments across sectors or countries. Source: World Resources Institute; Global Commission on Adaptation 2020; BCG analysis

### With actions over 7 key areas to improve resilience

Source: BCG analysis based on data from the 2022 Climate Disclosure Project Climate Change Questionnaire (n = 400 responses); From Risk to Reward report of Dez/2023

### **Business &** Community Water Infrastructure Energy Food Health 3

**Biodiversity** 

#### Selected resilience measures

- Supply chain resilience
- Climate analytics & forecasting
- Disaster preparedness, planning and training
- Climate insurance
- Water use monitoring & efficiency
- Water collection and storage
- Water quality monitoring and treatment
- Protection against flooding
- Infra resilience to extreme weather events
- Infra resilience to other climate risks
- Protection against heat
- Coastal protection
- Decentralized generation & storage
- Grid management and monitoring
- Cropping & integrated systems
- Soil management
- Fit-for-purpose on-farm and post-harvest storage
- Limiting in-store food waste
- Improving human and animal diet quality
- Management of heat-related illness
- Management of injury and mortality from weather
- Management of respiratory illness
- Management of diseases
- Protection of biodiversity hotspots
- Restoration and recovery of biodiversity hotspots
- Increased connectivity of biodiversity hotspots



#### Most frequent private sector invested measures



## Companies already implementing A&R measures over key areas achieved benefit-to-cost ratios ranging from 2:1 to 15:1

				erannanteren er	Benefi	t-to-cost ration -	
Impact area	Adaptation and resilience measure	1.1	5:1	10:1	15:1	Overall	Emerging markets and developing economics
Water resilience	Water use efficiency technologies	•••	•			~2-6:1	~3-6:1
Water resilience	Water collection and storage					• ~31-53:1	~31-50:1
Infrastructure resilience	Adapted infrastructure to withstand flooding	•	• •			~2-7:1	~4-7:1
Infrastructure resilience	Green and gray infrastructure enabling adaptation to flooding	••		•	•	~2-15:1	~10-15:1
Food resilience	Regenerative agriculture	• •	•			~2-5:1	~5:1
Overall obse	erved benefit-to-cost ratio range Bene	efit-to-cost rat merging m <u>ark</u>	tio observed tet and d <u>ev</u>	t in implementat eloping econ <u>omic</u>	tion B	enefit-to-cost ratio o nplementation <u>or in</u>	bserved in global advanced economics

Note: Analysis focuses on the benefits gained from adaptation and resilience measures – according to companies reports including cost savings from resource efficiency, revenue loss avoided through continued operations, and asset damage avoided - and does not consider broader social impacts or mitigation benefits that, taken together, may result in a higher benefit-to-cost ratio Source: BCG analysis based on data from the 2022 CDP Climate Change Questionnaire (n=20), From Risk to Reward report of Dez/2023



## Several examples of companies already identifying investment opportunities in A&R measures

Water Efficiency Technologies | Cost savings from drip irrigation and other low-flow technologies delivered an economic benefit-to-cost ration (BCR) of 2 to 6 globally and of 3 to 6 in EMDEs. Such measures are particularly critical in EMDEs in sub-Saharan Africa and Latin America, the two regions that are expected to see the highest growth in water demand by 2050<sup>1</sup>

Water Collection and Storage | Rainwater harvesting systems and other alternative water collection measures that ensure continued operations during times of water stress delivered and economic BCR of 31 to 53 globally and of 31 to 50 in EMDEs. The high BCRs on this measure reflect the magnitude of value at risk that companies report from revenue loss due to water shortages.

Adapted Infrastructure to Manage Flooding<sup>2</sup> Elevating, reinforcing, and retrofitting infrastructure delivered an economic BCR of 2 to 7 globally and of 4 to 7 in EMDEs. This is critical in EMDEs where expansion of urban areas and new cities requires resilient infrastructure, achieved by embedding physical risks in planning and design<sup>3</sup>. Although costs are front-loaded, benefits accrue over many years through reduced start-stop spending, maintenance costs, and repair costs. The BCRs in our analysis are in line with those of the Global Commission on Adaptation, which estimates a range of 2 to 10<sup>4</sup>.



Green and Gray Infrastructure to Adapt Other Assets to Flooding Measures to absorb or divert floodwater delivered an economic BCR of 2 to 15 globally and of 10 to 15 in EMDEs<sup>5</sup>. The upper end of the BCR range reflects implementation of hybrid nature-based solutions combined with gray infrastructure solutions, which have been shown to provide lower-cost and more resilient services<sup>6</sup>.



Regenerative Agriculture | Combining practices such as agroforestry, cover cropping, and no-till farming can deliver an economic BCR of 2 to 5 globally, with the upper end of the range occurring in a project based in an EMDE. This project was financed through a public-private partnership in which injection of public capital lowered initial private investment.

1. World Resources Institute (2023), 25 Countries, Housing One-quarter of the Population, Face Extremely High Water Stress 2. Based on EU taxonomy classifications of adapted investments versus investments enabling adaption 3. OECD (2018), Climate resilient infrastructure 4. Global Commission on Adaptation and World Resources Institute (2019), Adapt Now: A Global Call for Leadership on Climate Resilience 5. Based on EU taxonomy classifications of adapted investments versus investments enabling adaptation 6. Climate Adaptation Platform (2023), "Green-grey Infrastructure Solution for Urban Stormwater Management."



# Even so, there is still a massive gap in A&R investments, and preparedness levels from actors

Tracked global funding for adaptation by source (2021/22 average, \$B)





#### National Governments

- Only  $\sim 27\%$  of countries have submitted full National Adaptation Plans to UNFCCC<sup>2</sup>
- Even those with NAPs face challenges ~50% of NAPs fail to include implementation strategies



#### City Governments

- Only 573 cities globally have reported on their A&R plans<sup>3</sup>
- Those that do often fail to accurately incorporate climate risk and define actionable mitigating levers

#### Private Companies

- ~12k of companies globally have disclosed risks associated with climate change in 2023; ~52% of total that disclose climate initiatives
- Yet, there is still only 2% of private investments in A&R



# Unlocking capital to invest in A&R requires identifying the right mix of funders

Cash flow generating projects

Projects generating real financial return

Projects with carbonoffsetting benefits

- Development of climate data and tools can be licensed or sold at a profit
- Private sector is well-positioned to infuse capital into these A&R efforts

• Solutions where ROI is based on carbon markets that facilitate the trading of emission allowances

• Nature-based solutions and regenerative practices generate credits that can then be sold to governments/private sector

Non-cash flow generating projects

Projects that increase resilience of a company

'Public good' projects

- Solutions that protect business assets/supply chain/revenue stream attract corporate investment
- If these projects are too large/risky, public-private partnerships can be leveraged to enable private sector investment
- Solutions that require concessional financing and a mix of loans
- Ideally suited for governments in partnership with bilateral agencies, DFIs or public climate funds





National governments to enable sub-national governments in planning and implementing A&R efforts through policies and ensuring sufficient funding and sovereign guarantees



All have a role to play in enabling A&R measures



Subnational governments, including cities, states, and regions, need to implement a portfolio of localized A&R projects that ensure resilient infrastructure, services and communities, and risk management

Private sector to invest in A&R implementation developing projects that protects assets, allows growth & go beyond financial results by partnering with governments on mutually beneficial A&R projects for the public

Funders to invest in pool of A&R investment opportunities:

- Government funders and corporates to leverage growing opportunities for traditional cash-flow-generating projects
- Donor agencies to provide grants for feasibility studies, technical assistance and other forms of concessional funding for public goods projects



\$

Civil society and other organizations (e.g., NGOs, academia, philanthropy) need to provide technical capabilities, funding for A&R projects, and advance research and education to encourage behavioral change by the public



# There are strong imperatives for both public & private sectors to act on adaptation & resilience

#### Public sector imperative

#### Assess climate risks and implement the most-needed A&R actions to protect people economies, and natural ecosystems



#### Social

To prepare and protect people from climate impacts, especially vulnerable communities (e.g., low-income groups, women, indigenous communities)



#### Economy

To ensure livelihoods and industries can thrive amidst climate disasters and to minimize economic losses and damages (e.g., damage to infrastructure)



#### Nature

To safeguard ecosystems, resources, and biodiversity from the effects of climate change (e.g., coral bleaching, damaged mangroves, endangered species)



#### Protect

To build business resilience and safeguard value at risk, protecting assets, supply chains, and operations by implementing and financing A&R measures

#### Private sector imperative



#### Grow

To capitalize on new and growing business opportunities that rise from A&R action (e.g., developing climate resilient products)



#### Participate

To collaborate with the public sector to finance and implement capital projects and deploy finance toward vehicles that support a portfolio of projects.



## Public-private collaboration is critical to deliver high-impact A&R action at pace and at scale

#### Dual use tunnel in Malaysia

- Collaboration between gov. & 2 private infrastructure companies
- Malaysian govt. launched call for proposals to build tunnel to **protect** from flash floods
- Innovative idea to monetize tunnel for road traffic enabled coinvestment for 1/3 of the funds in exchange for toll rights

#### Desalination for water-stressed communities

- Collaboration between El Jadida (Morocco) and OCP (national Phosporus company)
- Morocco is set to face water scarcity challenges
- OCP is investing in desalination facilities & wastewater treatment facilities + offers excess capacity of its Jorf Lasfar plant to supply clean drinking water to population in El Jadida

#### Policy-driven A&R investments in power grid

- Finnish power grid operator & government of Finland
- Change in govt. regulation, stipulating max. duration of power outage by zone, accelerated investment in making power grid resilient
- Elenia financed investments worth €1B by monetizing future cost savings



#### Digitized power grid for bushfire prevention

- Endeavour Energy (grid operator in Australia)
- Overheated cables can spark **bushfires** & floods leaving people without power for days due to long visual inspection times
- Implemented digital twin of power grid can optimize preventive vegetation mgmt. & run remote flood simulations, restoring power timely & safely



# Although Brazilian government has developed some A&R initiatives, country must drive multi-level engagement

Non exhaustive



2016

Launch of the first A&R program (PNA<sup>1</sup>), covering 11 sectors, including agriculture, cities, disaster risk management, etc. Government investments of R\$ 10.4B to adaptation projects through Climate Fund



2023

Framework for A&R was defined during COP28, setting stage for global discussion

2025

Climate Plan is under development, with strategy to be designed in 2 key pillars - Mitigation & Adaptation - expected to stabilish goals, actions & trackers for 2035



To prepare for changes to come, Brazil needs to define goals & actionable plans, coordinating measures with private sector securing resources to invest in A&R

2024 by Boston Consulting Gr



### Brazil stands at a crucial point in its climate journey, with Climate Plan outlining goals & revising NDCs by 2025

### Climate Plan

Set to launch in 2025, the plan will guide Brazil's climate policy through 2035, outlining strategies to reduce GHG emissions and adapt to the increasing impacts of climate change

#### Mitigation Strategy

Aims to establish national GHG emissions reduction targets<sup>1</sup> for 2030 and 2035, defining cost-effective emissions trajectories

To be unfolded into 7 Sectoral Mitigation Plans - i.e., main emissaries - each with specific targets and actions aimed at reducing emissions

#### Adaptation Strategy

Aims to reduce vulnerability to climate change impacts by promoting adaptive capacity and resilience

To be unfolded into 15 Sectoral Mitigation Plans, each with specific actions and targets to enhance resilience to climate impacts

Transversal Strategy

#### NDC revision

The Climate Plan will revise Brazil's NDCs with a more ambitious goal for 2035, to be launched before COP30, aligned with Paris Agreement to limit warming to 1.5ºC<sup>2</sup>











Financing, regulations and investments needed



Necessity for education, R&D<sup>3</sup> and innovation



Monitoring, evaluation and transparency measures

1. Brazil's current NDC targets: 1.32GtCO2e (2025), 1.2GtCO2e (2030), Net Zero Emissions (2050) 2. The Global Stocktake is a process to assess global progress toward the Paris Agreement goals, conducted every five years. The first-ever stocktake, discussed at COP28 in 2023, concluded that the world is off track to meet the 1.5°C global warming target 3. Research and Development Source: UNFCC; Governo Federal Brasil; BCG Analysis



# Besides developing national goals, Brazil's hosting of COP30 can help meet ambitious commitments

Brazil leadership in global events will enhance its role in advocating for decisive actions ...



... providing environment for dialogue that leads to substantial shifts in all countries commitments towards 2030/2035 ...

... given that major progress is needed on concrete actions for global energy and climate transition (e.g. climate finance) ...

... at the same time, offering concrete and ambitious projects to materialize Brazil's key comparative advantages...

... presenting a business opportunity to boost and fund global Net Zero & Adaptation efforts



## Case Study: Biofuels



### Biofuels play an important part to achieve a NZ future, with opportunity to transform the transport sector in Brazil

### Biofuels opportunity

Biofuels can support **emissions** reduction in transport, power and heating, helping achieve net-zero

There is high potential to further reduce emissions & participate in carbon markets through BECCS<sup>1</sup>

Brazil is already a top producer, benefiting from high productivity & vast areas for sustainable expansion

### Brazil's potential

**(**\$)

By 2050, Brazil could supply up to 110% of transport energy demand with biofuels

Leading to a 55% reduction of emissions, able to become climate positive with BECCS

Creating space for investments of up to \$ 200 B in additional capacity

### Key enablers

Potential can be achieved with full feedstock use, enhanced yield & degraded pastureland restoration

Supported by continued advances in regulations, blending mandates, incentives & capabilities

Sustaining a compelling case for investment for national & international players



# Biofuels use renewable feedstocks to power the transport sector and generate heat and electricity

				1 <sup>st</sup> Gen Feedstocks	2 <sup>nd</sup> Gen Feedstocks		Not exhaustive	
			Main production pathways	food crops	residues/waste	Drop-in?		
ional Jels		Ethanol	Fermentation and distillation of sugars, starches and cellulosic biomass	Sugarcane, Corn, Wheat, Beets	Agricultural residue, Switchgrass	$\bigcirc$	Blended (w/gasoline) standalone in FFVs <sup>1</sup>	1,
Traditi		Biodiesel	Transesterification (FAME <sup>2</sup> ) of vegetable oils/other lipids; coprocessing in refineries	Soybean, Palm, Rapeseed or Sunflower oils	Animal fats, UCOs³, Non-edible oils	$\bigcirc$	Blended w/diesel; few engines run B100	0
iomethane HVO/SAF		Renewable Diesel (HVO <sup>4</sup> )	Hydrotreatment (HEFA <sup>5</sup> ) of vegetable oils and other lipids	Soybean oil, Palm oil, Rapeseed oil	Animal fats, UCOs, Non-edible oils,			
	Sustainable	Hydrotreatment (HEFA) or Fischer-Tropsch synthesis of vegetable oils and other lipids	Soybean oil, Palm oil, Rapeseed oil	forestry residues, MSW, Algae <sup>6</sup>				
	Aviation ruer (SAP)	Alcohol-to-Jet (AtJ) conversion	Ethanol (1G)	Ethanol (2G)				
		Renewable Natural Gas (RNG)	Upgraded from biogas (byproduct of anaerobic digestion of waste/residues)	Maize and grass silage	Agricultural residue, Animal fats, UCOs, MSW, Sewage sludge			

Note: Biobutanol, biomethanol, and bio-LPG are also derived from biomass and can replace fossil fuels, but were not included since their fuel usage is less significant. 1. FFVs = Flex Fuel Vehicles can operate on gasoline and any blend of gasoline and ethanol up to 83% 2. FAME – Fatty Acid Methyl Ester 3. Used Cooking Oils 4. Hydrogenated Vegetable Oil 5. Hydroprocessed Esthers and Fatty Acids 6. Other specialized/niche solutions with advanced feedstocks are under development, listed above are the most technically feasible

# Offering an immediate & efficient path to reduce emissions, with routes still relevant to compete in NZ future

Subsectors		Share of energy emissions <sup>1</sup>		Low-carbon main offers			
				Short Term (2030)	Future Outlook (2040+)		
	<b>6</b>	Light Road	10%	22%	Ethanol is the immediate solution for NZ; EVs are gaining relevance, but still costly for developing countries	EVs to become the main tech incentivized by policies & NZ ambition; ethanol still relevant for countries with lower electrification levels	
Transport	<b>.</b>	Heavy Road	7%	27%	Biodiesel is the most developed & ready technology; NZ solutions gaining relevance with new policies	Drop-in & low-carbon fuels - HVO, Fuel cells - likely to become the fuel of choice, in line with NZ goals	
	X	Aviation 2%		2%	SAF-HEFA is the most promising solution under development, but still costly to be applied at scale	SAF-HEFA to become mainstream while AtJ gains scale and feedstock limitations support $\rm H_2derivatives$	
		Shipping	2%	1%	Limited renewable options, biodiesel is the readiest technology, but with low use at scale; HVO has increasing relevance with advance of new policies	Drop-in solutions should gain traction, especially biomethane, bio/e-methanol, HVO and ammonia	
		Rail	1%	1%	Biodiesel is the most developed & ready technology, electrification as an opportunity to reach NZ goals	Advancements in the industry can impulse electrification; RGN & fuel cells as key fuels for sector	
Power & Heat <sup>2</sup>		Industry	42%	6 42%	Biogas/RNG is the immediate solution for this hard-to- abate sector, leveraging available natural gas infrastructure	RNG to maintain its relevance, with potential growing use of $\rm H_2$ with market development	
	4	Electricity			Solar & Wind plants are the bet alternative to decarbonize the power sector	Solar & Wind to remain the most relevant, combined with batteries to cope with intermittency	

1. Following world transport emissions per subsector as disclosed in UFCCC report. Share of Brazil emissions considers 412.5 M ton CO<sub>2</sub> e in energy in 2022 2. For Global, it considers the emissions in energy for industry & buildings use (residential & commercial). For Brazil, it considers energy emissions from industry, commercial & residential use Source: IEA World Energy Outlook 2022; IPCC Sixth Assessment Report 2021; BEN (National Energy Balance) 2022; Climate Watch; SEEG; BCG Analysis



# Biofuels can further reduce emissions, seizing the market opportunity for carbon removal with BECCS



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### Brazil is already a top producer of ethanol and biodiesel, and is unveiling its potential for HVO, SAF and RNG



1. CONAB data from 4th sugarcane report of 2022/2023 crop 2. ANP/ABIOVE 3. Estimated considering emissions if energy demand of ethanol production was replaced by gasoline & biodiesel production was replaced by diesel 4. As disclosed by ANP in Biomethane authorization panel in 09 of September of 2024 Source: CONAB; ANP/ABIOVE; ANP – Biomethane panel; SEEG 2022; Press releases; BCG Analysis





### Feedstock productivity and land availability give Brazil a competitive edge to grow in the biofuels market

Brazil supplies biofuels with top tier productivity...

...and a vast area of degraded pastures for sustainable expansion



1. Land used for cultivation of crops only. It does not include land potentially cultivable but not normally cultivated. 2. Considered 50% of sugarcane land to produce ethanol and 12% of soybean land to produce biodiesel Source: USDA; Index Mundi; World Bank; Observatory of Economic Complexity; FOFAO; IPEA; Atlas das Pastagens 2022; MapBiomas Brasil; BCG analysis

# Looking forward, there are different roles for biofuels in Brazil...

k				
Ethanol	Biodiesel	HVO	SAF	Biomethane
Brazil is already a global leader; new technologies expanding the 2G market, with export potential	Likely following global trend, demand will shift to advanced fuels in the future (e.g., HVO)	Great feedstock potential positions Brazil as a global supplier for both 1G & 2G fuels	Brazil could lead production via the most viable pathways, HEFA & AtJ, with export potential	Brazil regulation favors domestic usage, with logistical costs currently limiting exports
Demand for SAF-AtJ can support future ethanol production despite EV expansion	Brazil can leverage its feedstock to produce both 1G & 2G fuels in any development case	Yet, policies are needed to define the local market and incentivize production	Recent policies favor expansion, but extended regulation is required to boost production	Supply chain development, from feedstock to off-taker, is imperative to capitalize on the market


## ...with potential to transform the transport sector by 2050

If Brazil uses its full feedstock potential, enhances yield & restores degraded land by 2050, it could:

Supply all Brazil's transport sector

+100% Supply of the energy demand



Reduce emissions in the transport sector

-55% of GHG emissions Reaching *Climate positive* with BECCS



Create significant market opportunities \$100-200 B Investments in additional capacity

.... While still addressing food security & land use concerns

#### 4 Biofuels' Case Study

Brazil's biofuels energy supply potential

## Brazil biofuels could supply all the domestic transport sector & export part of production

#### EJ Main dstocks • Sugarcane & corn • Soybean oil • MSW Sugarcane Bagasse Palm oil Filter cake Corn Soybean oil • Soybean oil Animal fat & UCOs Vinasse • Animal fat & UCOs Animal fat 4.2 0.7 1.7 0.9 0.7 1.8 0.8 1.9 Biofuels in 2023 Ethanol & Biodiesel HVO & SAF Biomethane Total Use full feedstock potential: Key levers Enhance crop yield: Restore degraded land: for Brazil Expanding advanced Following market best Repurposing applicable biofuels market fuels production & degraded pastureland expansion 2G feedstock & current trends to crops

Note: Production in 2023 considers ethanol, biodiesel and biomethane. Additional energy production for each fuel was estimated according to the key levers for the feedstocks listed, by 2050. Proportion of food use of 1<sup>st</sup> gen feedstock was maintained. "Restore of degraded pastureland" lever is based on 2024 study from EMBRAPA, with ~28 Mha to be restored for agriculture purposes 1. Reference of 3.8 EJ in 2022, based on IEA – World Energy Outlook of 2023 2. Comparisons are not necessarily cumulative with supply of Brazil transport sector demand 3. Estimated value of ~25 B L by IEA – Renewables in 2022 Source: Ministry of Agriculture; CONAB; UNICA; IBGE; EMBRAPA; FAPESP; Nova Cana; EPE; BNDES; SEEG; IEA; "Agricultural Expansion in Degraded Pasture Lands" of 2024; BCG Analysis

## +100%

of Brazil transport sector energy demand in 2022<sup>1</sup>

Key comparisons<sup>2</sup>

+4x

~85%

~80%

Ethanol volume production in 2023

of global HVO and SAF demand by 2027<sup>3</sup>

of Brazil NG demand in 2022 supplied by biomethane

74





## Recovery of pastureland enables expansion of biofuels and ensures food security

#### Potential uses for recovered pastureland Mha



1. Mapbiomas 2. Estimated based on Griscom, 2020 & Roe 2021, according to BCG Forestry NZE 2050 projections in Brazil 3. Estimated area considering lever "Restore degraded pastureland" for biofuels expansion, following guidelines from EMBRAPA study "Agricultural Expansion in Degraded Pasture Lands" of 2024 and a proportion of 12% of soybean crop to fuel, 50% of sugarcane crop to etanol and 42% of palm oil to fuel 4. Considering 282.5 Mha as of 2022 5. Considering 51 Mha as of 2022 Source: "Agricultural Expansion in Degraded Pasture Lands" of 2024; Conab; BCG analysis





### Key biofuels' levers can create a solid path to decarbonize transport sector, reaching negative emissions with BECCS

GHG emissions comparison for transport sector with biofuels full potential estimates Mton CO<sub>2</sub>e, GWP-100



1. Estimated considering biofuels production with implementation of the 3 key levers disclosed, multiplied by the carbon intensity of biofuels per feedstock. As supply in 2050 surpasses transport demand, the matrix was completely replaced with biofuels 2. Considering total CO<sub>2</sub> liberated in ethanol fermentation, following stoichiometric reaction & anaerobic fermentation from biomethane production, considering ~40% of biogas is CO<sub>2</sub>, for both production it was estimated a recovery of 90% of CO<sub>2</sub> generated Source: US EPA; RenovaCalc; SEEG; BCG Analysis

### Brazil could create significant opportunities for investments

**\$100-200B** 

Investments in additional capacity by 2050

### Direct investments in additional biofuels capacity $_{\mbox{USD B}}$



Note: Capex only considers fuel production – according to EPE study & recent projects - not including spends for crops, R&D, land purchase, logistic development & storage. For BECCS, investments considers the cost for capture, dehydration and compression of CO<sub>2</sub> without additional separation processes. For sugarcane ethanol, it was considered a mix of 50%/50% for green & brownfield projects, in mixed plant production (i.e., sugar & ethanol). For corn ethanol considers full ethanol plants. All technologies investments are expected to be impacted by effects of the learning curve that range from 0.5 to 2.5% a.a. Source: EPE 2032; Press search; Experts inputs; CEBRI; IEA; BCG Analysis



## Seizing opportunities is key, as the maturing of emerging NZ paths can stabilize biofuels expansion in the long-term



Increasing demand and policies already favoring low-carbon solutions will continue to drive growth of biofuels use, taking advantage of the matured technologies and markets



Evolution and maturing of lower emission paths, such as Green H<sub>2</sub>, Fuel cells and E-Fuels, will increase competition, potentially stabilizing growth of biofuels in the longrun, but uncertainty remains

78



## To unlock potential, Brazil should continue advancing its policies and capabilities

#### Advance mandates & regulations

- Increase existing blending mandates  $\overrightarrow{A} =$   $\underline{\Delta}$  and establish blend targets for advanced fuels
- Define regulations for carbon storage in natural resources

#### Incentivize compatible engines

- Expand tax breaks and offerings of flex-fuel vehicles

#### Develop supply logistics

- Build pipelines and enable grid injection 🛕



Ethanol &

biodiesel

#### Boost 1G 💉 🖦 🛪 🛕

- Sustainably expand agriculture into degraded pastureland
- Continue efforts to enhance crop yield

#### Prioritize 2G 💉 🖦 🛪 🛕

• Develop technologies to boost 2G feedstock (i.e., nonfood crops, waste, residues)

#### Invest in R&D

- Reach tech maturity in next gen biofuels (synfuels, e-fuels) ➡ ズ
- Invest in technologies for carbon capture, storage & usage

Biomethane

BECCS



#### Biofuels' Case Study

## Beyond longstanding incentives for traditional biofuels, Brazil is developing goals for HVO, SAF & RNG

#### 2019 RenovaBio

National policy promoting biofuels, sets emission targets and establishes a national certification entity and carbon credit market (CBios)

#### 2021

#### Fuel of the Future<sup>1</sup>

Complements RenovaBio by expanding blending mandates and creating programs for other biofuels (SAF, HVO, RNG), fostering sustainable low-carb and developing a framework for CCS

ETS (cap and trade)

Pending

The Brazilian System of Emissions Commerce (SBCE) introduced in 2021 the framework for a national carbon market and allocation plan, yet policies for sectors and clear decarbonization targets are still pending

1. Combustível do Futuro 2. As approved by the Senate on September 4, 2024 Source: Press search; BCG Analysis





## Brazilian biofuels make a compelling case for investors





Biofuels are an attractive opportunity

Brazil has distinct capabilities



Current challenges being addressed



Diverse investment options

- Advancements in climate agenda: fossil fuel-dependent countries with ambitious decarbonization targets could leverage biofuels
- Developed market: biofuels are a low-carbon ready solution for sectors like transport, power & industrial heat

- High yield crops: Sugarcane and soybeans leading global production
- Available land for expansion:
  ~100 Mha of degraded
  pastures available for recovery
- Green matrix: Power supply with ~88% renewable sources

- Tech evolution: Boosting crop production and advancing tech to diversify feedstocks
- Policies under development to make Brazilian biofuels price-competitive externally
- Advanced fuels: Internal development & incentives for advanced/2G fuels markets

- Safer: Established projects with consistent returns, e.g., E1G/E2G, Biodiesel
- Higher-Risk: Innovative with high growth potential, i.e., HVO, SAF, RNG
- Capital Requirements: Projects tailored to varying investor capabilities

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# Thank You



Brazil Climate Summit.