A NEW ECONOMY FOR A NEW ERA:

ELEMENTS FOR BUILDING A MORE EFFICIENT AND RESILIENT ECONOMY IN BRAZIL

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NEW ECONOMY FOR BRAZIL

This study pinpoints policies that can help reduce poverty and inequality, contribute to the achievement of economic and sectoral goals, stimulate sustainable economic growth and make Brazil more resilient to future pandemics and other risks, such as climate change and ecosystem destruction. This document is, first of all, a summary of the latest economic data on measures to meet these goals, as Brazil, like many countries, seeks opportunities to boost economic growth, especially after the COVID-19 pandemic.

The study was developed in two complementary parts. Initially, a thorough literature review was conducted, analyzing the benefits and opportunities of policies in three main sectors: infrastructure, industry and agriculture. Then, based on economic modeling, new results are identified should measures to support the transition to a low-carbon economy be adopted. In addition, the study presents evidence showing that by mainstreaming sustainability as a cross-cutting policy in the planning and implementation of related investment decisions, Brazil could benefit from trends in the financial markets and widen access to private finance.

How and when Brazil builds a more efficient, resilient, fair, and sustainable economy will be a decision taken by each facet of the Brazilian society. The intent of this study is to present a series of compelling elements showing that Brazil has never been better able to implement this new economy, and that the country and its people have much to gain from it.

This study was led by **WRI Brasil** and **New Climate Economy (NCE)** teams and conducted in partnership with Brazilian experts and institutions, namely: the Pontifical Catholic University of Rio de Janeiro (**PUC-RJ**), the Climate Policy Initiative (**CPI**), the Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering of the Federal University of Rio de Janeiro (**COPPE/UFRJ**), the Institute for Applied Economic Research (**IPEA**), the Brazilian Federation of Banks (**FEBRABAN**) and the Brazilian Business Council for Sustainable Development (**CEBDS**), a representative in Brazil of the World Business Council for Sustainable Development (**WBCSD**).

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EXECUTIVE SUMMARY

Elements for Building a More Efficient and Resilient Economy in Brazil

The world is currently facing an unprecedented convergence of crises. The COVID-19 pandemic and related social and economic crises aggravate the vulnerabilities generated by low economic growth, growing inequalities within and between countries, and the climate crisis. COVID-19 has highlighted the importance of robust risk management and shown just how interconnected people, communities and the economy are as a whole.

Brazil is no exception. The resources mobilized for economic recovery at the national and subnational level will be an historic opportunity to increase the country's capacity to generate jobs, productivity and economic efficiency, to boost social inclusion, to preserve natural capital and to improve public health.

This study brings evidence showing that Brazil is ready to adopt this new economic course, without disrupting important sectors, by applying existing technologies, laws, or bills pending approval. This new path is also aligned with a low-carbon economy.

Although the study was initiated shortly before the COVID-19 pandemic, the urgency of post-crisis economic recovery makes it even more timely. The goal is to identify economically viable paths to build a more modern, sustainable and inclusive Brazil within an unfavorable fiscal context. Therefore, it focuses on identifying competitive advantages and opportunities that could help transition Brazil towards a new economy more suited to twenty-first century challenges, including climate change. Ignoring these opportunities and advantages may lock-in the country to technologies and models that will soon prove obsolete.

The study was developed in two parts. The first presents three sectoral paths for the transition to a low-carbon economy in Brazil. Each path creates immediate and lasting economic, social and environmental opportunities that are relevant particularly to an economic recovery scenario. Sectoral recommendations include:

- **Quality infrastructure** – Promoting integrated planning of projects consistent with the maintenance of natural capital, thus improving economic and societal resilience to increasingly common extreme climate events, and enabling the mobilization of private investments;

- **Industrial innovation** – Adopting green technologies and approaches as future growth opportunities in industrial sectors. These approaches will use Brazilian knowledge and capacities, and will generate drivers of innovation and productivity growth for the industrial sector;

- **Sustainable agriculture** – Implementing measures to increase efficiency in agricultural production bring several benefits: more efficient land use, increased production and productivity, reduced pressure to deforest, and renewed confidence of consumers and national and international markets increasingly concerned with environmental and climate issues.

The second part of this study consists of showing short, medium and long-term results of an economic modeling exercise that projects the impact of sustainable measures on each of these sectors.

The contributions presented have the potential to create millions of jobs, leverage sustainable and competitive growth in Brazil and reduce poverty and inequality.

If adopted, they will make strategic sectors of the Brazilian economy even more productive and competitive at the global level. At the same time, these sectors will become more resilient to the negative impacts associated with deforestation, environmental degradation and loss of natural capital, which threaten human well-being. Below are some highlights for each of the sector-specific policies discussed throughout the study.

Quality Infrastructure

Infrastructure is the bedrock of any economic and social system. Nations are increasingly seeking solutions that meet economic and social needs while protecting the environment - solutions such as renewable energy, natural infrastructure, low-carbon cities, and more efficient transportation. For Brazil, investing in modern, quality infrastructure is an economically smart choice. On the one hand, quality infrastructure reduces the costs and impacts of environmental degradation. On the other, it allows future infrastructure to be more resilient to increasingly extreme and frequent weather events (e.g., floods, droughts and fires).

Quality infrastructure could help fulfill the current government's priorities of fostering productivity and competitiveness and increasing international trade. In 2017, Brazil lost 2.4 million tons of soy and corn due to inadequate infrastructure, a loss of R$ 2 billion (PÉRA, 2017). A study by the Climate Policy Initiative (CPI) estimates that it would be necessary to invest 2% of GDP in improving cargo transport infrastructure to remedy this problem, but the country would recoup its investment in three years and thereafter realize savings each year (ANTONACCIO *et al.*, 2018).

Quality infrastructure also creates conditions for the expansion of investment across relevant sectors. The measures proposed by the Ministry of Economy, regarding the use of social discount rates for infrastructure projects and the drafting of bills to establish new governance for the planning and implementation of investments in infrastructure and logistics, are signs that the country is beginning to lay the foundations for this development path (CHIAVARI *et al.*, 2019). However, as financial resources to build the infrastructure that the country needs are scarce in a recession, it is important to bear in mind that a competitive advantage, and also a risk, are entailed.

The advantage lies in the ample existing supply of natural infrastructure (e.g. forests, mangroves, and rivers), which has been proven to reduce overall costs of investments in infrastructure and logistics, if natural resources are used in a smart way. This study shows, for instance, that if the implementation of natural infrastructure for sanitation were optimized by territorial planning, the result would be rates of return on investment of between 13% and 28%, which are compatible with the investment rates of traditional sanitation infrastructure.

However, in a country exposed to climate change, there is risk in prioritizing current infrastructure approaches without taking into account their inadequacy when it comes to increasing extreme events and emerging technological standards. The consequence of not taking climate risk into account is that they are perceived by potential investors as possible future stranded assets, making it even harder to attract private capital and finance.

Finally, not opting for sustainable, climate smart infrastructure could lock the country into an infrastructure model that is old fashioned and would quickly translate into delayed and inefficient social and economic development.

Promoting Innovation by Opting for Sustainable Technologies

Policies to foster new innovation in Brazil have the greatest chance of transforming the economic recovery plan into an opportunity to modernize and rejuvenate underprivileged regions in the short- and medium- term. This transformation involves significantly reducing inequality in access to basic services and markets, which could happen through existing green technologies in Brazil. With adjustments to the regulatory framework and investments, these technologies could thrive and increase access to national and international markets.

One of the greatest opportunities for Brazil to modernize underdeveloped regions in the short- and medium-term, as discussed in this study, is through innovation in the industrial sector based on low carbon solutions in clean and smart transportation and renewable energy. This could be achieved by promoting Brazilian made technologies that operate on a small scale. Low-carbon solutions could also gain market share and prominence through regulatory advancements or significant investments.

Despite Brazil's privileged position in terms of renewable energy availability, the industry and transportation sectors still rely heavily on the use of fossil fuels. Such dependence is in many cases unnecessary as alternatives can have a positive impact on the economy and spur local development. For thermal energy, the use of distributed renewables or biomass fuels can provide logistical advantages over the use of fossil fuels, especially in locations that are far from large consumption centers and lack infrastructure.

For example, the Gold Standard, which certifies environmental projects, reported that an energy bundling project in Ceará State has switched the fuel used by five ceramic factories from illegal firewood to agricultural and industrial residues. This switch generated US$ 4.5 million in revenues for local communities, improved working conditions, increased water availability and avoided deforestation of 1,750 hectares in ten years, in addition to reducing greenhouse gas (GHG) emissions by 36,173 tons of carbon dioxide equivalent (CO_2e) per year (GOLD STANDARD, 2019).

Brazil is also in a privileged position to take advantage of its natural gas for use in the shipping industry, which is increasingly used by the global maritime industry to replace bunker fuel in vessels, in part aiming to reduce atmospheric emissions from the sector

(SZKLO *et al.*, 2018). However, despite Brazil's plentiful natural gas resources in the pre-salt region, commercialization is hampered by logistical barriers to entry and distribution in the Brazilian energy market (ALMEIDA, 2017). Investments could also be made to improve the machinery and liquefied natural gas (LNG) storage system on vessels, to remove these logistical barriers and to develop systems for the supply of natural gas for use in vessels.

Electric buses, both for urban mobility and potential exports, represent another opportunity for low-carbon development and competitiveness in Brazil. The production chain of this asset, including batteries, recharging stations, renewable energy generation and improvements in the electricity distribution infrastructure, results in direct and indirect job creation. Experts identified that there are no major bottlenecks for the Brazilian industry to produce electric buses (SLOWIK *et al.*, 2018), and the implementation of adequate public policies could attract private sector investments, increase scale-up and reduce cost barriers. It is, therefore, an example of a sustainable opportunity with feasible implementation that could mean a leap forward in innovation for Brazilian industry.

The transition to low-carbon energy technologies is a strong 21st century trend. It is no longer a matter of *if*, but of *when* it will happen.

This is made explicit mainly by the fact that it is already among the pillars of China's and Europe's post-COVID-19 economic recovery plans. Brazil is also in a position to take advantage of this trend in favor of its development, harnessing its natural capital and resources to boost economic growth and industrial productivity.

Transition to More Sustainable and Resilient Agriculture

Brazil is currently the third largest agricultural producer in the world and the second largest exporter of food (FAO, 2018). Agribusiness[1] accounts for one in every three jobs in Brazil and was responsible for more than 22% of Brazil's Gross Domestic Product (GDP) in 2018 (CEPEA, 2019). It is, therefore, critical to consider the negative externalities and risks that could impact the sector´s production, productivity and competitiveness. Many of these risks are of domestic origin and mitigating them requires cultural changes related especially to deforestation, *latifúndios* (large unproductive or under-utilized estates), and use of less efficient agricultural techniques.

Sustainable agriculture is more resilient, as it reduces deforestation and environmental degradation, and it also increases water and land efficiency. As a result, it can ensure water security for the sector and the country. This is strategic for Brazil's long-term development.

There is scientific evidence that deforestation of 20% to 25% of the Amazon biome could lead to "savannization", a scientific term for "tipping point". This tipping point would cause substantial and unpredictable changes in rainfall patterns in northern, central-western and southeastern Brazil (LOVEJOY and NOBRE, 2018), with a strong impact on the agriculture sector. This risk can and should be addressed and managed during the post-COVID-19 recovery period.

1 Agribusiness is defined as "the sum of four segments: inputs for crops and livestock, basic or primary agricultural production, agro-industry (processing) and agro-services". The analysis of this set of segments is made for the crop/ vegetable and livestock/animal sectors (CEPEA, 2019).

This study shows that in no other sector are the advantages of a rapid transition to a low-carbon economy as strong as in agriculture.

National and international consumers have shown unequivocal signs of the value they place on environmental preservation. Brazil's opting for a deforestation-free agricultural expansion that uses more efficient and intensive means of production could represent, at the same time, a leap towards sustainability, productivity and competitiveness of its already strategic agrobusiness sector.

For example, of the 200 million hectares of pastureland in Brazil, experts from EMBRAPA, the Brazilian Agricultural Research Corporation, estimates that nearly 75% have some degree of degradation (EMBRAPA, 2019). However, cattle ranchers declared in the 2017 Agricultural Census that only 12 million hectares of pasturelands are degraded (IBGE, 2019). The discrepancy between the perception and analysis of experts from EMBRAPA and the perception of the cattle ranchers reinforces the lack of adequate Technical Assistance and Rural Extension. Out of every four hectares destined for livestock in Brazil, three of them have no kind of assistance and extension (IBGE, 2019). The result is that at least 50 million hectares produce only half of its potentially supported capacity (EMBRAPA, 2019).

Therefore, a major challenge for this sector is not necessarily lack of technology, but rather lack of access to technical assistance. The investment required to restore 12 million hectares of pastureland – the amount of land declared by rural producers as degraded in the 2017 Agricultural Census (IBGE, 2019) – would be approximately R$ 25 billion. Estimates made in this study indicate that this investment, if applied over ten years, with a discount rate of 8.5% per year, would generate a positive net present value (NPV) of R$ 19 billion, with just over six and a half years to payback, and potential additional benefits of R$ 742 million in tax revenues.

Another example has to do with the Brazilian forestry sector. The economic development of this sector, with large-scale planting of native species (native species silviculture), has the potential to position Brazil as a world leader in tropical timber exports. In addition, it would help the country meet national and international commitments, such as the Paris Agreement, as well as enable new business opportunities through carbon credit markets and other environmental services.

This is because, in addition to capturing carbon by increasing forest biomass, there would be a reduction in erosion and soil fertility loss, improving water quality and availability and reducing illegal deforestation for timber production. As a result, economic growth and the creation of jobs in rural areas would also be benefits of developing such a local bioeconomy.

One way to take this leap toward more productive, competitive, sustainable agricultural and forestry sectors in Brazil is to translate the scientific evidence – i.e. methods that increase productivity while preserving natural capital – into policies that make these benefits clear to rural producers, technicians, consultants and companies in the agricultural sector.

For example, subsidies and incentives could be redirected to activities associated with high productivity, sustainable and low-carbon practices, as well as technical assistance. Using credit incentives in a smart way is also critical. For instance, the study indicated that unless rural credit is made conditional on environmental performance, with subsidies for those who concretely foster positive environmental and social externalities, there are few financial incentives to spur agricultural intensification.

The Benefits of a New Economy for Brazil

This study presents the socioeconomic benefits that could be achieved with the adoption of a broad set of policies around sustainability. The results are encouraging.

The economic modeling carried out to evaluate the benefits was initiated before the COVID-19 pandemic, when the challenges of low economic growth and high unemployment rates in the Brazilian economy were already being seen. That said, the basic modelling results still stand. GDP growth is likely to be negative in 2020, given the economic crisis, but these new economic pathways offer Brazil a stronger and better economic recovery trajectory and employment boost than a business-as-usual (BAU) based recovery.

The analysis shows that sustainable and low-carbon practices can lead to significant GDP growth, with a total accumulated gain of R$ 2.8 trillion by 2030 compared to BAU.

Adopting these measures could lead to a net increase of more than 2 million jobs in the Brazilian economy in 2030 when compared to BAU, yielding benefits from the very first year. Such measures would also lead to a reduction in GHG emissions exceeding Brazil's current commitment for 2025 under the Paris Agreement.

Three scenarios are outlined in this study, each of which incorporates increasing degrees of intensity and penetration of these economic transition measures:

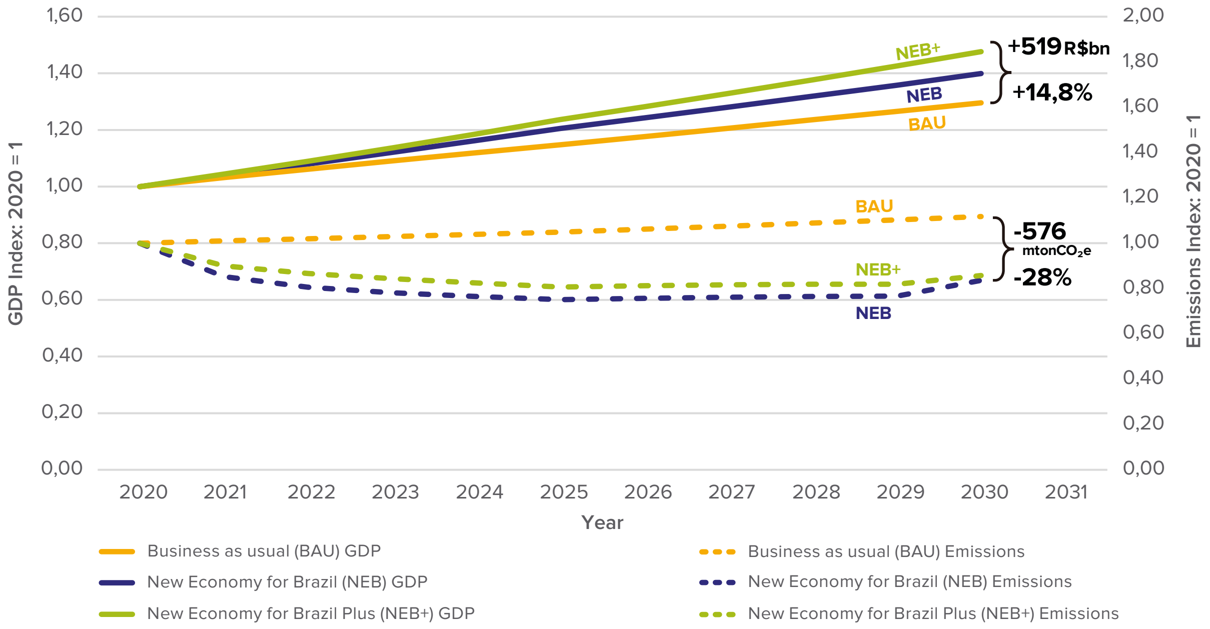
1. **Business as Usual (BAU)**;
2. **New Economy for Brazil (NEB)**, which encompasses a series of low-carbon measures. Such measures include increased use of hybrid and electric vehicles, increased use of charcoal in the iron and steel industry and reducing food loss while maintaining the same level of agricultural production. All together these measures result in a decrease in cropland area and an increase in natural vegetation, through restoring degraded lands, and they also reduce the pace of deforestation;
3. **NEB+**, a scenario similar to NEB, but whereby half of the land that would return to native vegetation in the NEB scenario is instead used for high productivity agriculture, increasing agricultural production over BAU. This scenario also leads to reduced pressure for deforestation compared with BAU.

GDP growth is likely to be negative in 2020, given the economic crisis, but these new economic paths offer Brazil a stronger economic recovery path and more jobs compared to BAU.

Moreover, the NEB and NEB+ scenarios explored in the economic modeling show that the net social, economic and environmental benefits start to accrue as soon as low-carbon investments are implemented, right from the first year. Therefore, they can be an important part of the effort to help Brazil build back better from COVID-19.

Figure ES1

GDP growth and CO_2e reduction under NEB scenarios



Source: Prepared by the authors.

Overall, this study finds that traditional Brazilian sectors are well placed to become even more competitive globally by increasing productivity and promoting activities free of deforestation and environmental degradation. Natural capital provides resources and enabling conditions for Brazil to have a promising economic future. Therefore, protecting this unique resource is not only possible but essential for the country to recover and grow in a sustainable and robust manner in the short- and long-term.

The study also reveals that opting to make sustainability a crosscutting issue would create an additional opportunity for Brazil to leverage scarce public resources by crowding-in green finance for much-needed investments. This opportunity emerges for two reasons. First, as national and international private investors are increasingly shifting away from high-risk, unsustainable projects, this change in approach would allow greater access to private finance for Brazil. Second, Brazil has sophisticated private and public institutions, and existing policies and regulations that can be enhanced to help create pipelines of sustainable projects that can back the issuances of green securities to fund them.

Therefore, a transition to a new economy would benefit key sectors of the Brazilian economy, help the country gain more international market share and improve infrastructure in times of global recession. As countries mobilize resources to revive their growth and build better and more resilient economies for the future, this green growth path that once seemed remote or disruptive now appears prudent and safe. Now is the time for Brazil to take a new course towards a more prosperous, modern and equitable future.

Box SE1

The social and economic benefits of a new economy for Brazil

A green economic recovery will allow Brazil's economy to grow more over the next decade than the current development model. By 2030, compared to business-as-usual, a low carbon, climate resilient economic recovery in Brazil could deliver:

A net increase of more than **2 million jobs**

A total GDP gain of **US$535 billion** (R$ 2.8 trillion)

Restoration of **12 million hectares** or more of degraded pasturelands

US$3.7 billion (R$ 19 billion) in additional **agricultural production**

US$144 million (R$ 742 million) in additional tax revenues from **the agricultural sector alone**

A **42% reduction in greenhouse gas** (GHG) emissions in 2025, compared to 2005 levels

Increased access to **to international financing and private investment**

A reduction in **air and water pollution, with benefits for the health of Brazilians as a result**

More resilient livelihoods **and food security in the face of extreme climate events**

Source: Prepared by the authors.

1

INTRODUCTION

1.1 Current Country Context and Ongoing Economic Challenges

The 2020s have had a turbulent start. The Brazilian economy was struggling to get out of a crisis when it plunged into a much deeper, global crisis caused by the COVID-19 pandemic. This is an unprecedented moment in this century due to the magnitude of the impacts of the pandemic on the economy, society, health, science, education, and the environment. Important social issues in Brazil have worsened, such as access to health, transportation, and income generation.

The cost of economic recovery implies a substantial increase in public debt. As investment capacity is limited, investments must be strategic in order to benefit critical sectors, especially those that result in greater job creation, less inequality, and a low-carbon economy. That said, the decade has begun with a unique economic advantage for Brazil: there is clear interest and demand from international investors for the maintenance and better management of Brazil's natural capital. This, combined with the production of food, energy, and investment opportunities in sustainable business, are on a scale rarely seen in other nations.

This study shows that Brazil already has traditional sectors positioned to increase productivity and to become globally competitive precisely because of its capacity for green growth[2] compatible with international demand.

2 In 2009, during the Ministerial Council Meeting of the Organization for Economic Cooperation and Development (OECD), several countries signed the "Declaration on Green Growth" aiming to accelerate initiatives that integrate economic, socio-environmental, development, and technological aspects. This document presents a way to promote economic development while natural wealth is secured to provide environmental services.

The transition to a more sustainable and resilient growth model only improves these sectors of the Brazilian economy, such as agriculture. The transition can help the country to gain market share internationally and improve the infrastructure that serves Brazilians and facilitates agriculture, mining, and energy. In the medium and long term, modeling scenarios show that this transition would cost Brazil less than maintaining the current development model.

In recent decades, Brazil advanced its socioeconomic indicators due to the global price stability trend and the reduction of poverty and income inequality. However, the country's growth was below the average of other emerging economies between 1995 and 2016 (WORLD BANK, 2019; ABRÃO, LISBOA and CARRASCO, 2018).

In 2012, the Brazilian economy began to show signs of decline, with deceleration, stagnation, and reversal of previous advances. In 2015, Brazil entered a deeper and more challenging recession followed by a slow recovery in growth that revealed the decoupling of its economic performance from international trends, especially compared to other major economies. The Brazilian labor market was significantly affected. Between 2014 and 2018, the average rate of unemployed workers almost doubled, reaching 12.5% (IBGE, 2019a).

Historically, the slow national economic growth was caused mainly by the slow increase in Brazil's productivity growth rate (RIBEIRO and NUCIFORA, 2017; SOUSA and OTTAVIANO, 2017; LISBOA *et al.*, 2010; MATION, 2014). This is associated with a low labor and capital productivity (factors of production) in industry and agriculture. Amid the country's serious fiscal crisis and the global economic context, Brazil must be pragmatic but also bold and creative in the coming years.

One of the advantages of adopting a green growth model is its positive effects on factors of production – land, labor and capital – and the ability to generate jobs.

In addition, one of the main factors for long-term economic performance is the country's infrastructure. Brazil lags far behind in global social and economic infrastructure and logistics indicators (WORLD BANK, 2017), especially compared to G20 countries and the group composed of Brazil, Russia, India, China, and South Africa (BRICS).

The insufficiency and low quality of Brazil's infrastructure generates significant economic costs and losses for productive sectors, as shown by losses in agriculture generated by inadequate transport and logistics (PÉRA, 2017; VIANNA and YOUNG, 2015; CINTRA, 2014). It also generates negative impacts on the productivity and health of workers, for example through impacts caused by air pollution (WHO, 2018). Emblematic national projects have not attracted investors and financing compatible with Brazil's potential, nor have they been able to consolidate an improvement in the provision of public services, despite the increase in public spending and the initiative of creating the Investment Partnerships Program (PPI) in 2016.

To overcome some of these major challenges, it is essential to (i) implement integrated logistics planning, (ii) strengthen governance of infrastructure, agriculture, and industry sectors, (iii) improve the legal and regulatory security of such sectors, and (iv) build an integrated portfolio of projects – with technical, economic-financial, and environmental consistency – that can mobilize fast-growing resources of funds and other opportunities in search of actions that value natural capital.

1.2 Objectives of the Study

This study analyzes Brazil's main economic challenges and proposes specific measures that support the transition to a more sustainable and resilient economy. Such actions build on national plans and strategies already underway.

The study points out competitive advantages and opportunities that can contribute to constructing a new economy for Brazil suited 21st century challenges, including climate change and the destruction of ecosystems.

This study shows how economic performance measured by traditional indicators, such as Gross Domestic Product (GDP), employment, productivity, income distribution, tax services, and access to finance, can grow without diminishing public resources and natural capital to the benefit of society's health and well-being. It focuses on how embarking on a low-carbon economic trajectory is fundamental to achieve, and go beyond, sectoral goals and priorities as identified in the 2020-2023 Pluriannual Plan (PPA)[3] and improve Brazil's position in the face of the downward economic trends of this century.

Brazil's 2020-2023 Pluriannual Plan (PPA) extends from 2020 to 2023. According to the document, the main barriers to be overcome include the high "Brazil cost" resulting from excessive bureaucracy and tax burden, few incentives for the private sector to produce and invest, deficient and inefficient infrastructure, several logistical bottlenecks, and low productivity and competitiveness due to a limited commercial and financial economy (BRASIL, 2019b).

In turn, it is crucial to integrate social and environmental issues to overcome these barriers. The National Strategy for Economic and Social Development (ENDES 2020-2031)[4], which aims to guide, articulate, and influence discussions of other policies of national development planning, indicates that there is evidence of economic benefits obtained by environmental protection (BRASIL, 2019b). Furthermore, the Triennial Plan 2020-2022 (of the National Bank for Economic and Social Development, BNDES) shows opportunities for social advances and growth through the strategic use of natural assets, which is capable of generating long-term social, economic, and environmental sustainability (BNDES, 2019).

This study is primarily a synthesis of the most recent economic evidence on measures that meet these objectives, as Brazil and many countries seek opportunities to boost economic growth especially after the COVID-19 pandemic.

Ths study also includes a macro-econometric model to quantify the overall social and economic impacts if sustainability became part of a broader strategy. It goes on to detail specific policy opportunities to attract the short, medium, and long-term investments needed. And, to highlight how the different recommendations in this study can be incorporated into Brazilian federal institutions, this study also includes a Policy Entry Point analysis to demonstrate the feasibility of moving towards a low-carbon economy.

3 The Pluriannual Plan (PPA) is the legal instrument for public planning, which reflects the government guidelines for a period of four years, established in the Federal Constitution of 1988. Under the terms of § 1 of art. 165, the PPA "establishes, in a regionalized manner, the guidelines, objectives and goals of the federal public administration for capital and other expenses arising from them and for those related to programs of continuous duration" (BRASIL, 1988).

4 The National Strategy for Economic and Social Development (ENDES) aims to guide, articulate and influence the discussions of other instruments for national development planning (national, sectoral and regional plans and the PPA).

The analysis carried out in this study is consistent with government plans. However, it also indicates that accelerating the trajectory towards a low-carbon economy may be fundamental to achieving and exceeding the sectoral goals and priorities identified by the government. Finally, this study shows that such goals can be achieved without putting too much pressure on public resources while preserving the environment and enhancing society's health and well-being.

2

INVESTMENTS IN QUALITY INFRASTRUCTURE:

DRIVING GROWTH GAINS AND ECONOMIC, SOCIAL AND ENVIRONMENTAL DEVELOPMENT

2.1 Quality Infrastructure and the Maintenance of Natural Capital

Investing in quality infrastructure, as the Group of 20 key economies (G20) calls it, contributes to making the priorities of the current Brazilian government feasible, namely fostering productivity and competitiveness and increasing international trade.

Infrastructure projects demand strategic decisions as they imply long-term planning and determine the country's future economic and technological structure. Emerging and developing economies, such as Brazil, tend to be more susceptible to risks caused by extreme weather events (heavy rains, droughts, landslides, etc), as they have less resilient infrastrucuture and less advanced mechanisms to prevent and cope with natural disasters. Sustainable infrastrucuture can significantly increase resilience, especially that related to climate change[5].

5 Nature based solutions such as the conservation of native forest areas, forest restoration and sustainable landscape management.

From 2013 to 2017, more than half of Brazilian municipalities declared Emergency Situations or States of Public Calamity (MARCHEZINI, 2019). Data show that droughts affected about 48.6% of Brazilian municipalities, flooding affected 31%, and flash floods or mudslides affected 27% (IBGE, 2018). It is estimated that between 1995 and 2017 about US$ 34 billion (R$ 180 billion) was spent on response activities and/or recovery from these events (S2ID, 2019). In January 2020, record torrential rains in the Southeast caused losses estimated at US$ 573 million (R$ 3 billion).

In Brazil, natural disasters cause loss and degradation of existing infrastructure. Given the scarcity of investment in the sector, it is extremely important that government actions prevent such impacts from becoming a stronger trend. Hence the importance of new infrastructure being resilient, of lasting quality, and built using sustainable materials.

Another potential impact of climate change on Brazilian infrastructure relates to water resources. Hydrological cycles are directly related to temperature variations and incidence of solar radiation. In the last two decades, there has been an 80% increase in the volume of raw water captured for multiple uses in Brazil. This percentage is expected to increase by 24% by 2030 (ANA, 2018). The results from an unfavorable water balance can lead to periods of water crisis due to scarcity. This was clearly the case in 2017, when droughts affected 38 million people in Brazil (ANA, 2017). Changes in rainfall patterns, and consequently the flow of the country's rivers, can also seriously impact Brazil's energy sector, especially hydroelectric generation which accounts for about 65% of the annual electricity generation (EPE, 2018). Therefore, in addition to careful and effective management of water resources, it is essential that infrastructure investments consider the risks associated with short and long term environmental impacts.

When it comes to infrastructure, integrating natural solutions has great potential. It is especially important to consider the effects of accelerated depreciation of natural capital, particularly in a country so rich in natural resources. In Brazil, this approach can help the country to achieve its sanitation goals more affordably, efficiently, and enduringly.

Forests, for example, can provide water purification and erosion control services. Forest restoration in certain degraded areas can be an ally of stable water supply, improving the quality of water that reaches treatment plants and consequently reducing the costs to public companies of sanitation (FELTRAN-BARBIERI *et al.*, 2018). If adopted on a large scale in Brazil, this approach to infrastructure can generate many gains for the environment and economy (Box 1).

Box 1

The Potential of Natural Infrastructure

Natural infrastructure is defined as physical structures that produce, stock, pack, and make resources available directly to their users. Examples include thermal comfort, carbon storage and stock, packaging of pollinators, and protection of soil and water. Natural infrastructure as a complementary strategy to man-made structures in the provision of essential services for urban sanitationand drainage is extremely relevant.

In terms of water, one third of studies have found that natural infrastructure increases aquifer reload capacity. Of the more than 200 studies that tested the influence of native vegetation on hydrological dynamics in rural and urban areas, including Brazil, 33% attested that natural infrastructure increases aquifer recharge capacity. 83% reported increased infiltration of water into the soil, positively affecting fundamental services related to planning the supply of urban water and industrial and agricultural production (FILOSO *et al.*, 2017).

These services have positive impacts that go beyond well-being and health. In terms of economic benefits, the techniques of quantification and economic valuation of services provided by natural infrastructure reveal accessible economic gains. Whether delivered through cash generation or cost containment, these gains can be significant. Forthcoming work by the World Resources Institute (WRI) estimates that the restoration of 12 Mha of native vegetation could generate annual savings of US$ 897,000 (R$ 4.7 million) in chemicals.

This economic gain is generated by the replacement of pastures for forests. When managed inadequately, pastures discharge sediments into water bodies. This increases turbidity and creates the need for the use of coagulants and disinfectants. Native vegetation is a natural filter, preventing surface flow and soil loss, and delivers less turbid water to reservoirs and treatment plants. If the inverse relationship is statistically consistent, Brazilian native vegetation currently promotes water prefiltration services equivalent to US$ 42 million (R$ 220 million) per year. The replacement of pastures for forests could be limited to extreme cases of degradation, in which its effect on the landscape causes double damage through low livestock productivity and soil carrying to waterways.

Natural infrastructure planned on a regional scale has valuable benefits. Studies conducted at the watershed level of the Cantareira Systems (the main supply for the Metropolitan Region of São Paulo) and Guandu (the main supply for the Metropolitan Region of Rio de Janeiro) reported that the improvement on water quality due to restoration measures could provide a reduction cost of about US$16-17/hectare (R$ 82-89/hectare) of pasture per year. Both projects are economically viable, even if the sanitation companies used their own discount rates to invest on installing natural infrastructure (including forest restoration). Furthermore, if the installation was done only on pastures with maximum levels of degradation, optimizing the terriorial planning, it would result in a retun on investment rates ranging from 13 to 28%, which is compatible with investment rates on sanitation infrastructure.

2.2 Economic and Social Consequences of Past Investment in Logistics and Infrastructure

The decrease in investments in infrastructure and logistics (I&L) has been one of the most consistent economic trends in Brazil for at least three decades (CNI, 2016; FRISCHTAK, 2019). Since the 1980s, investment in I&L has shrunk from more than 5% to just under 2% of GDP. This rate is not even able to cover depreciation of assets (FRISCHTAK and MOURÃO, 2017).

According to recent estimates, in the next two decades Brazil should invest about 4.2% of its GDP to fill the I&L gap (FRISCHTAK, 2019). This has profound consequences for the quality and productivity of human and physical capital, and therefore for the productivity and competitiveness of the economy in general. The lack of investments in I&L is one of the most significant obstacles for Brazil achieving the Sustainable Development Goals (STUDART and RAMOS, 2019).

A new opportunity to remove some of the obstacles to expanding investments in infrastructure is to define priorities in a plan for investments in quality infrastructure – that is, investments in infrastructure that are well shaped to development needs, financially adequate and attractive to investors, that help reduce GHG emissions and are more resistant to extreme weather impacts (AMIN *et al.*, 2019).

A recent study by the Asian Development Bank Institute (ADBI), with the participation of several Brazilian experts on quality infrastructure, proposed policies and guidelines to stimulate quality infrastructure and internalize environmental costs: (i) promote research and commitment to deforestation-free development, (ii) promote upstream planning internalizing social and environmental risks and costs in the development of the project pipeline and that considers the added value of ecosystem services and nature-based solutions, (iii) finance principles and rules that encourage the conservation of land, water, and biodiversity, and (iv) develop small-scale projects in the Amazon that support local development and alleviate poverty (ADB, 2020). Low-quality infrastructure creates significant obstacles and bottlenecks for Brazil's economy and social progress. For example, the high costs of transport and cargo logistics, resulting from deficient, outdated, and unbalanced transport types, reduce the country's international competitiveness as well as competition and efficiency in the domestic market. Additionally, low quality urban public transport and high dependence on private motorized transport reduces productivity in cities, due to traffic, long travel times, high accident rates, and high levels of air pollution.

Besides being economically sub-optimal, low-quality infrastructure is socially detrimental. Air pollution, primarily from vehicles and heavy industry, causes around 50,000 deaths each year in Brazil. This is equivalent to the annual death toll from violence and traffic accidents, the latter of which takes about 45,000 lives and costs about US$ 7.6 billion (R$ 40 billion) per year (IPEA, 2015). For large national urban centers, there are approximately 20,000 premature deaths due to air pollution each year. This costs Brazil US$ 1.2 billion (R$ 6 billion) annually in health costs, which is about 5% of the Ministry of Health's budget in 2019 (MIRAGLIA and NOGUEIRA, 2014). Health costs can be significantly reduced through investments in clean and efficient public transport which reduces congestion and improves air quality, especially in large urban centers.

In the case of cargo, Brazil's territorial vastness presents a costs challenge for agribusiness. It also poses a challenge to the implementation of quality infrastructure and logistics projects. It should be noted that the transport modes matrix in Brazil is unbalanced. In 2015, according to the National Logistics Plan (PLN) 2025 (EPL, 2018), road transport represented 65% of cargo transportation in Brazil, followed by railways (15%), waterways (5%), cabotage (11%), and pipelines (4%). Such a disproportionate distribution contributes to inhibiting the country's growth.

An example of this problem relates to the transportation of agricultural products that are essential to the Brazilian economy. On average, agricultural exports in Brazil travel around 1,500 km overland to reach a port – primarily by highway. In addition to an excessive dependence on trucks, poorly maintained highways and inadequate transport and storage cause losses of millions of tons of harvested soybeans and corn each year. Losses reached 2.4 million tons in 2017, amounting to cost of just over US$ 382 million (R$ 2 billion) (PÉRA, 2017)[6]. But a study of the Climate Policy Initiative (CPI) in cooperation with the Inter-American

6 Losses were calculated based on the "opportunity cost" – unrealized sales (94.3% of total value) – and unnecessary logistics expenses. The numbers depict 2015, but waste is continuous. The need to transport grain using trucks, most often by unpaved roads in precarious conditions, causes a large volume of soybean and corn losses along the way.

Development Bank (IDB) estimated that an investment of 2% of GDP in infrastructure for cargo transportation would be recouped in just three years (ANTONACCIO *et al.*, 2018).

Another byproduct of the decrease in public investment over the last decades is the decline in the quality of public institutions and agents' capacity in planning, developing, and implementing more complex projects (CASTELAR PINHEIRO and FRISCHTAK, 2014). This partial loss explains governments' limited ability, primarily that of subnational entities, to evaluate the complex technical issues posed by private investors who bid for larger projects. The loss of public power and the limited number of players with an understaning of structuting and development may have prevented private participation in transport infrastructure and logistic projects. Improving such capacity may be one of the most significant challenges that Brazil has ahead in expanding infrastructure investments. Another has to do with the mobilization of private financing, which is discussed next.

2.3 How to Improve Quality Infrastructure Financing

The fiscal crisis limits the potential of infrastructure investments from national and subnational governments. Consequently, the mobilization of private investment and private financing is essential to achieving the infrastructure investment planned by the federal government under the PPA 2020-2023 (BRASIL, 2019a; 2019b).

For example, quality infrastructure policies and guidelines fully incorporating social and environmental costs for project selection and preparation can create enabling conditions for such additional investments.

This "smart from the start" approach encourages investor confidence through clear standards and can lead to increased access to private finance (STUDART and RAMOS, 2019).

For instance, between August and October 2019, the Ministry of Economy conducted a public consultation on the calculation of the Social Discount Rate (SDR) over the adoption of cost-benefit analysis for evaluation and prioritization of infrastructure projects. It aimed to maximize Brazil's competitiveness (Box 2).

The use of a standardized rate is fundamental for comparability between projects, and consequently for the prioritization of alternatives and portfolios according to the criterion of socioeconomic present value (BRASIL, 2019a).

Box 2

Setting the Social Discount Rate for Infrastructure Investments

The return rate of private capital (the main SDR component) incorporates an average market risk premium. However, this risk premium may be different from the risk premium of projects in sectors such as transport infrastructure, sanitation, education etc., in which the public sector typically invests. This may occur because, on the one hand, society as a whole may have a different risk tolerance from that of the private sector (especially on environmental issues) and, on the other hand, because projects in specific regions and/or sectors may have different risks.

Given risk differences (execution, operational, and environmental) of projects in different regions and/or sectors, this is an important route for improving SDR estimates and their suitability for the specific realities of Brazil. This differentiation between social rates of return of regions and sectors is factored into the definition of the social discount rate of other countries, such as the United States of America and Chile, and their incorporation could be an important gain for the methodology. Projects in the Amazon, or projects with a high associated climatic risk, could have differentiated treatments if these variables were incorporated into SDR (BRASIL, 2019a).

Source: Bragança, 2019.

In addition, investing in quality infrastructure can “open doorways” to new types of projects. Infrastructure investments can be a vector for developing countries to boost their economies, generate jobs, and address socio-environmental challenges (BIVENS, 2017).

Given that the Brazilian government plans to develop and implement a series of major projects in the coming years and that some of these projects are in the Amazon, an assessment of socioenvironmental risks to reduce them is very strategic to the country's economic growth. It is also essential to review the current regulatory framework and improve the decision-making process over the implementation of an infrastructure project (ANTONACCIO *et al.*, 2018).

The inclusion of actors that promote better environmental and social management practices allows better governance of infrastructure investment in Brazil. There are bills under consideration in the National Congress that aim to establish the legal-regulatory framework capable of attracting strategic investments for new infrastructure in the country. As highlighted by Chiavari *et al.* (2019):

“There is an opportunity for an integrated debate to ensure the future of better infrastructure for the country with environmental conservation, taking as its starting point these bills”. One of the main gains of a systemic view, in light of the three bills, is the ability to visualize more precisely the challenges faced throughout the life cycle of an infrastructure project.

In particular, there is the possibility of improving technical, economic, and environmental feasibility studies by anticipating the discussion of issues that are currently dealt with only during environmental licensing. This could provide more robust and higher quality projects, promoting investment security and ensuring socio-environmental protection (CHIAVARI *et al.*, 2019).

It is important to rethink governance for infrastructure investments in Brazil. This must involve a shift towards a smarter regulatory framework aiming to reduce political interference and increase transparency in the definition of contractual agreements, budget, and revenue structures.

One example is the Investment Partnership Program (PPI), created by Law nº. 13,334/2016. Its objective is to expand and strengthen the interaction between the State and the private sector to enable and leverage Brazilian infrastructure to attract private investments, especially from foreign investors (BRASIL, 2016). The Program established a new governance flow for prioritizing and monitoring projects that could be carried out through privatization, concessions, and Public-Private Partnerships (PPPs). It focused on implementing concrete measures and actions that could stimulate economic growth and generate jobs and income through investments in the infrastructure sector.

The PPI was designed to be the first contact of investors with the Brazilian government. It presents a portfolio of projects detailing technical, economic, financial, and environmental aspects, and serves as an articulation hub within the scope of various stakeholders (investors, industry associations, financial agents, international bodies, public service concessionaires, state and municipal governments, embassies of foreign countries, environmental licensing bodies, control

bodies, legislative power, regulatory agencies, and sectoral ministries). It is a locus for promoting (i) dialogue and transparency, (ii) risk management and project supervision, (iii) technical improvement of projects, (iv) legal and regulatory improvement of contracts, and (v) regrowth of a long-term vision that provides predictability to investors (BRASIL, 2016).

The Program has attracted investors, especially foreign ones. In its first 36 months, there were 248 qualified projects, of which 147 had signed contracts. In the same period, R$ 260.2 billion in investments were contracted, and R$ 54.1 billion were collected in grants and signature bonuses. Of the 147 completed projects, 55 were contracted with foreign winning companies or in consortium with Brazilian companies, accounting for 85.7% of investments contracted. Among the countries that participated in the infrastructure assets of the Program, in addition to Brazil, were Italy, Portugal, United States, China, Norway, Australia, United Kingdom, France, Qatar, India, Bermuda, Spain, Switzerland, Germany, and Colombia (PPI - May/2019; VASCONCELOS, 2019).

Two measures are worth highlighting for the purposes of this work: the implementation of long-term planning and the introduction of analyses of environmental issues at the start of the project stgructuring (VASCONCELOS, FORTUNATO, 2019). The first measure is the resumption of integrated logistics planning seeking to provide predictability for investors and society. The publication of a previous concession schedule ensured the predictability of investment decisions, with emphasis on the oil and gas and electricity sectors, mainly transmission line concessions. It was in this context that the National Logistics Plan (NLP) 2025 (EPL, 2018) emerged.

The NLP is a dynamic and comprehensive plan. It focuses on the movement of cargo that circulates in Brazil on the various types of transport based on information of origin and destination, logistics corridors, demand projections, and the corresponding distribution in the existing and future infrastructure of transport. The Plan was prepared by the *Empresa de Planejamento e Logística SA* (EPL) with the participation of several government agencies and private institutions and Ipea supported by preparing demand projections. An objective, among others, was to identify logistical bottlenecks and to be able to direct, in a technical way and free from political pressures, resources (mainly private) towards investments that best contributed to reducing these bottlenecks – through, above all, concessions – contributing to the reduction of the Brazil Cost and helping the country to achieve sustainable and competitive growth (VASCONCELOS, 2019).

The second initiative concerns the consideration of environmental issues at the beginning of project structuring by adjusting schedules and avoiding delays due to environmental licensing. A specific unit was created within the Secretariat of the Investment Partnerships Program (SPPI) to manage and promote environmental issues: The Secretariat for Supporting Environmental Licensing and Expropriation. Thus, conditions were created to strengthen the treatment of environmental issues at the start of the Technical, Economic and Environmental Feasibility Studies (EVTEA) of each project, increasing the predictability and structuring more robust and higher quality projects.

Such actions are relevant mainly in regions such as the Amazon, where estimates indicate investments needs of R$ 367 billion in infrastructure in the next few years. However, large-scale infrastructure is believed to be one of the main drivers of illegal deforestation, either directly by cutting vegetation or indirectly by creating incentives for a disorderly occupation of adjacent territories and the flow of people for construction.

Deforestation is no longer an externality to be mitigated, but has become a condition for access to credit (VASCONCELOS, 2019). Supporters of commitments against deforestation in the Amazon include agribusiness companies, investors in projects and pension funds, and investors in sovereign wealth funds.

Another advantage of promoting quality infrastructure is that it can help to fill long-term financing gaps in infrastructure and logistics.

To mitigate problems and take advantage of all opportunities, such as access to finance and innovation, it would be ideal for Brazil to have a national plan that integrates aspects of sustainability across its entire line of infrastructure projects, especially in the Amazon (VASCONCELOS, FORTUNATO, 2019). In June 2020, the federal government issued a decree aiming to encourage projects with social and environmental benefits through measures that simplify the eligibility of projects for the issuance of “infrastructure-backed debentures” (BRASIL, 2020a). This measure focuses on projects in the sectors of energy, urban mobility, and basic sanitation. It can be a relevant milestone to attract private investments (national and international) to quality infrastructure projects.

3

LOW-CARBON INDUSTRIAL INNOVATION OPPORTUNITIES

Industry is one of the sectors in which Brazil has the greatest chance of transforming its economic recovery plan into an opportunity to modernize and transform deprived regions in the short and medium terms. This transformation involves significantly reducing inequality in access to basic services and markets. This could happen through domestic technologies, which only need adjustments in the regulatory framework and further investment to increase access to national and international markets.

The opportunity for Brazil to modernize underdeveloped regions in the short to medium term lies in the innovation of the industrial sector based on low-carbon solutions. The transition to a new economy involves the production and use of innovative materials and processes that drive better performance and that use renewable natural resources and national labor, thus reducing environmental impacts.

There is, for instance, enormous potential to increase investments and foster strategic incentives in renewable energy and low-carbon transportation. In addition to improving the environment, such investment can address a long-standing problem of the local industrial sector: its low rate of innovation prevents Brazil from increasing its energy efficiency and the population from having greater access to electricity. During the period from 2012 to 2014, only 39% of continuous-process industries and 40% of discrete-process industries displayed innovation. The global average of innovation for the respective types of industry was 48% and 51% (CNI, 2017a).

There are important innovation opportunities to be explored in the renewable energy, transportation, biofuel production, and construction sectors, and the following section will highlight some examples.

3.1 Industrial Innovations in Renewable Energy

Industry, in general, demands large quantities of fossil fuels in its transformation processes. In many cases, this represents large costs related to the acquisition of energy resources and transport from the origin to the consumption center.

The use of local renewable resources can present key opportunities to reduce costs and provide increased competitiveness. In addition, the use of renewable sources can realize several socioeconomic and environmental co-benefits.

Brazil has a privileged position in terms of availability of renewable energy resources. This is reflected in its energy matrix and in its electrical matrix: in 2018, 45.3% of energy production was from renewable sources, a figure well above the global average, which was 13.7% (EPE, 2019). In the case of electricity, 83.3% of production was from renewable sources, while the global average was 24% (EPE, 2019). Despite Brazil's privileged position in terms of availability of renewable energy, the industry and the transport sectors still depend heavily on fossil fuels. However, this dependency is, in many cases, unnecessary. Alternatives can positively affect the economy and stimulate local development. In addition, Brazilian industry has a relatively low rate of innovation compared to that of other countries (CNI, 2017). This can be an obstacle to the development of innovative solutions for local use of renewable resources by the industrial sector.

Reducing fossil fuel dependency presents opportunities to increase efficiency, reducing costs across an entire industry. That includes opportunities in the acquisition of energy resources, operation of logistics from origin to consumer centers, and eventual conversion of fuel into electricity, especially considering the currently high exchange rate devaluation. The use of local renewable resources may represent an important opportunity for cost reduction and the creation of a more inclusive economy.

For thermal energy, the use of fuels from biomass can provide logistical advantages in relation to the use of fossil fuels, especially in locations far from large consumption centers that lack infrastructure. Therefore, there are gains in economic efficiency and social benefits.

Another option of industrial innovation related to renewable sources is renewable microgenerator plants – systems in which electricity is produced in the consumer units themselves with renewable resources. On-site power generation enables the reduction of losses in transmission and distribution systems (IRENA, 2017; LIMA, 2012) and generates jobs ranging from equipment manufacturing to installation and maintenance of systems (FICHTER *et al.*, 2017; SORIA *et al.*, 2015). Given the poor conditions of roads in places with a high potential of local on-site production of thermal solar energy (Concentrated Solar Power - CSP), the production of on-site equipment is more appropriate than transporting fuel from ther regions (SORIA *et al.*, 2015). Thus, the installation of CSP equipment factories in these regions could also have a positive impact on job creation and local income.

The advantage of CSP over other renewable technologies, such as photovoltaic and wind, is that it allows greater dispatchability, avoiding the integration costs inherent to intermittent sources. However, this must be preceded by infrastructure expansion, especially transmission lines, training and labor. The Gold Standard, which certifies environmental projects, reported a Ceará renewable energy joint project replaced the use of illegal wood as fuel with agriculture and industrial waste in five pottery factories and generated US$ 4.5 million of income for local communities, improved working conditions and water availability, and avoided 1,750 ha of deforestation over ten years, and 36,173 tons of CO_2 emissions per year (GOLD STANDARD, 2019).

Another important innovation involves turning waste into energy. For example, biogas produced by anaerobic fermentation of organic matter that decomposes waste is composed mostly of methane, a molecule that is also the main component of natural gas. It is possible to generate electricity in thermal machines, such as gas microturbines, which can be installed in small-scale enterprises (20 to 250 kW) (PECORA, 2006).

In Brazil, there is an underuse of biogas produced in landfills. It is estimated that only between 7% and 20% of the gas generated is used for energy purposes (NASCIMENTO *et al.*, 2019). The use of biogas for electricity production is one of the guidelines of the National Solid Waste Policy (BRASIL, 2010), but the initiatives are still modest and do not include national production of equipment. Therefore, there is a need to import microturbines from other countries instead of generating jobs and local income (CAPSTONE, 2019; CGEE, 2009). In some regions, the expected social impacts can also be significant.

Furthermore, following this same reasoning of transforming waste into energy, it is also worth highlighting the opportunities for industry related to circular economy. Waste from the production and use of industrialized goods return as inputs to the production process, providing a greater efficiency in the use of resources and potentially greater competitiveness to the industrial sector (DI MAY; REM, 2015). Modern information technology instruments are great assets. This is especially true in the context of an Industry 4.0 which encompasses smart cities and smart manufacturing, which can either guide the necessary reverse logistics processes or rationalize production acoording to the real demands of society (CNI, 2017b).

An increase in the use of renewable energy sources in industry would drive innovation and productivity for Brazil's industrial sector. Brazil is already a powerhouse in terms of labor employed in the renewable energy sector, especially in the bioenergy chain (IREAN, 2019). Increasing the use of renewable energy would also be expected to positively impact job generation. That's because, in general, jobs in renewable energy chains have a greater labor intensity compared to labor intensity in fossil fuel supply chains (IRENA, 2019).

3.2 Industrial Innovations in Transport

There are several opportunities for sustainability to drive innovation in the transportation sector. For instance, Brazil's shipping industry is well-positioned to access the benefits of natural gas just as the global maritime industry has been pushing to replace the use of fuel oil (bunker fuel) in vessels with the aim of reducing atmospheric emissions (OAK; SZKLO, 2018). However, the great availability of natural gas in Brazil's pre-salt layer is hampered by barriers to entry and distribution in the energy market of Brazil (ALMEIDA, 2017). Both the motor design for liquefied natural gas (LNG) in current gas-powered ships, as well as the

embedded systems and technologies necessary for the use of LNG in vessel engines, are already avaiable (IMO, 2016). For Brazil to seize this opportunity, it is necessary to invest in improvements in engines and storage of LNG in vessels, as well as in the development of systems for the supply of LNG to ships.

Another opportunity in the transport sector lies in electric buses. They can be incorporated into urban mobility systems in Brazil in the short term. Brazil already has two electric bus manufacturers, one national (Eletra) and one international (BYD). Studies show that there are no major bottlenecks in Brazilian industry to produce these vehicles (SLOWIK *et al.*, 2018). Nevertheless, the investments needed to enable the use of this technology goes beyond vehicles and includes batteries, recharging stations, renewable energy generation capital, and improvements in electricity distribution infrastructure.

While costs of electric bus purchases are higher than conventional buses, the costs are mitigated during the vehicles' lifetime due to lower energy/km cost and maintenance, resulting in cost-competitiveness (MOON-MIKLAUCIC, 2019). When positive externalities associated with electric buses are calculated, the costs are even lower than that of combustion technologies.

The benefits of electric buses include local pollution reduction and its impacts on public health, reduction of greenhouse gas emissions, noise pollution, and improved user service.

Brazil is especially well suited to the use of electric buses, due to its low-carbon electric generation mix (SLOWIK *et al.*, 2018). Some Brazilian cities such as Campinas, Sao Paulo and Curitiba are already starting the transition to clean electric vehicles (WRI BRASIL, 2017).

Even if direct jobs tend to go down, as the process of producing electric vehicles is simpler than that of combustion buses, (IEA, 2020) the generation of jobs in the electrification chain is positive. Investment in public transport more broadly has the potential for significant economic return in terms of generated jobs, local development, access to opportunities, and support for vulnerable communities.

3.3 Industrial Innovation in Biofuel Production

Another important opportunity for Brazil to generate much-needed innovation in its industrial sector is related to biofuel production.

Globally, there is an important debate about land use change associated with biofuel production concerning the relationship between food, energy, and environmental sustainability. This debate takes place in parallel with the need to eliminate dependence on fossil fuels from the transport sector.

In the case of Brazil, sugarcane ethanol production and its expansion inside the country in the last decade occurred mainly by the replacement of pasture and other agricultural crops, with residual impacts on deforestation (PACCA and MOREIRA, 2009; WALTER *et al.* 2011; SOUZA *et al.*, 2015). Brazil now has the most successful case of adaptation of passenger cars to non-fossil fuels. Currently, about 24 million light vehicles, or 66% of the circulating fleet, run with flex engines.

Between 17 and 20% of all primary energy consumed is from biomass, especially biofuels and bioelectricity from sugarcane bagasse. In 2018, Brazilian ethanol and biodiesel production broke production records: 32.3 and 5.4 billion liters, respectively.

The Energy Research Company (EPE) attributes such ethanol growth to at least three highly correlated factors: (1) low international price of sugar, making the sugar/alcohol mix favorable to ethanol, (2) up until recently high oil prices due to exchange rate devaluation, maintaining the cost-effectiveness of ethanol, and (3) licensing of 2.5 million new flex vehicles. Biodiesel production especially benefitted from the requirement to meet the mandatory blend of B10 (10% biodiesel over diesel) (EPE, 2019).

However, attention needs to be paid to changes in the world scenario and the export restrictions that it may present. In the last decade, corn ethanol production in the United States of America has increased significantly, reaching 61 billion liters in 2017 (double that of Brazil). Of this, 54 billion liters were produced for the domestic market. At the same time, the European Union makes it difficult to produce low-generation, land-intensive biofuels without environmental traceability. The overturning of the decree that established the zoning of sugarcane outside the Amazon adds a risk to Brazil's ethanol exports (99.8% of sugarcane biofuel in Brazil is first-generation ethanol).

On the other hand, there are opportunities for new markets, such as the production of second-generation ethanol (E2G). The aviation sector can benefit from a trend towards regulation in favor of a transition to cleaner fuels. It is estimated that Brazilian companies spend between R$ 16 and R$ 20 billion annually on fuel for passenger and cargo airplanes. The average price of aviation kerosene is currently above R$ 1.5/liter. Fuel costs vary between 22% and 27% of the total cost. This is an opportunity that could equal 50% additional fuel consumption of the passenger vehicles in Brazil.

The country's best opportunities are in renewable hydrogenated diesel (HVO), biokerosene (BioQAV), and biojet. Currently, the cost of producing one liter of biojet is between R$ 3.5 and R$ 8.0 for commercial routes, and between R$ 5.0 to R$ 12.5 for less used routes (FREUVE, 2019). The national policy for biofuels, known as RenovaBio, is based on three main instruments that can target the aeronautical sector: the annual carbon intensity reduction goals (gCO_2/MJ) for a minimum period of ten years, the certification of biofuels, and the decarbonization credit (CBIO).

Another relevant opportunity is the development of ethanol fuel cells for long-haul trucks. Such vehicles are powered by an electric motor, which is in turn powered by a fuel cell. Fuel cell vehicles have considerably higher fuel energy conversion efficiency than internal combustion engine vehicles, and a longer range than that of electric vehicles that use batteries (DOE, 2019). Adopting this cargo transport model in Brazil offers the possibility of using ethanol as a source of energy (NISSAN, 2016). It would provide additional gains, reducing vulnerability to variations in international diesel prices as well as mitigating the significantly negative impact on the trade balance due to the need to import diesel, as Brazil's refineries do not have the capacity to meet the country's demand.

3.4 Industrial Innovation in Construction

Cement is the main material used in construction around the world. The cement industry is currently one of the most carbon-intensive, responsible for an estimated 7% of global carbon emissions. The large scale of traditional cement production, known as Portland cement, has a major impact on the local environment, especially during the mining process to extract its components. Currently, there are technologies capable of producing cement of a similar or even higher quality using residual raw materials, such as blast furnace slag from steel production, ashes from thermal power plants, and tailings of mining processes.

There are several material agglomerations under study and produced with different levels of technological readiness which can be substitutes for traditional cement. In the Brazilian case, geopolymeric cement is a strong example (GEO-POL, 2019). Its process has an energy consumption about 59% lower than that of Portland cement (BRASIL, 2017).

A central challenge is that all existing specifications and standards for concrete, as well as supply chains for cement products, are tailored to traditional cement production. Thus, barriers, including regulatory, logistics, technical, and product reliability need to be overcome for a broader adoption of alternative cement products (VAN DEVENTER; PROVIS; DUXSON, 2012).

There are also opportunities regarding energy efficiency in buildings. There are numerous benefits, some of which involve simple solutions already widely available in the market, such as green roofs, green plaster, reflective roofs, and insulation systems (JAIN, 2019; SHARMA, 2013). Others such as phase change materials (PCMs), kinetic facades, thermoelectric materials with varied conductivity, and new generations of glass, are still in the development stage (ASCIONE, 2017b; BUONOMANO *et al.*, 2015; GHAFFARIANHOSEINI *et al.*, 2013).

Financing energy efficiency in buildings is a constant challenge. Although there are initiatives, such as the Support Program for Energy Efficient Projects (PROESCO) of BNDES and the ANEEL's Energy Efficiency Program, experts identify financing as the main structural challenge of the construction sector. This sector is diverse and widely distributed, increasing the complexity of implementing energy efficiency measures. Such measures are usually carried out in large industries. The lack of technical and financial capacity limits performance contracts for implementing energy efficiency measures in buildings (CBCS, 2014).

4

ADVANTAGES OF LOW-CARBON AGRICULTURE

4.1 Brazil's Agriculture Sector

There are many good opportunitieis to promote industrial innovation and competitiveness in a low-carbon development strategy for Brazil – chief among them is the agricultural sector.

Brazil is a world leader in agriculture. It is the third largest producer and the second largest exporter of food in the world (FAO, 2018), and is at the forefront of technology and knowledge of land use. The Brazilian economy is largely shaped by and based on the agricultural sector. Agribusiness accounts for one in three jobs in Brazil. In 2018, it accounted for more than 22% of the Brazilian GDP (CEPEA, 2019). It is, therefore, crucial to take into account the negative externalities and risks capable of affecting the production, productivity, and competitiveness of this sector. Many of these risks are domestic in origin. Mitigating them requires cultural changes, especially regarding deforestation, *latifúndios* (which by definition of the land tenure structure in Brazil means a large area of private owned land), and use of inefficient techniques.

By 2050, Brazil is expected to become the country with the largest planted area globally (NELSON *et al.*, 2014). However, despite this leadership position, the agricultural sector is constantly questioned about the correlation between increased production and illegal deforestation in the Cerrado and Amazon biomes.

Brazil has natural advantages that allow it to increase the competitiveness of the agricultural and forestry sectors while conserving and restoring Brazil's ecosystems and natural resources and without making social or economic sacrifices.

Among the various opportunities, the following stand out: recovery of pastures and intensification of agriculture, reduction of food loss and waste, elimination of deforestation and forest degradation, restoration and reforestation of degraded areas and forests. Reductions in GHG emissions and GHG removal are also an important advantage in the context of creating a carbon market and a metric for risk analysts (WRI, 2019).

Studies such as that by the Brazil Coalition on Climate, Forests and Agriculture, have shown the commitment of important sectors of the Brazilian economy to a vision of sustainable rural development that includes producing more and better. These studies identify opportunities to create value from forests by ending illegal deforestation, recovering areas of degraded forests, making public policies feasible, and building aligned and integrated economic instruments (COALIZÃO, 2018).

In addition, the modernization of the national agricultural innovation system as well as the reallocation of industry expenditures for Research and Development (R&D) and innovation, can increase agricultural productivity without causing budgetary pressures (Box 3). More than 85% of the rural establishments in Brazil lack technical assistance and rural extension. Overcoming this enormous challenge is the starting point for a production revolution (IBGE, 2018).

This vision gains even more relevance because the Amazon rainforest is close to reaching the point of "savannization," or "tipping point." Studies have indicated that this point of no return could be reached by deforesting 20% to 25% of that biome and could cause substantial and unpredictable changes in rainfall regimes in the North, Midwest, and Southeast regions of Brazil (LOVEJOY and NOBRE, 2018). Some data shows that the Amazon has already lost approximately 18% of its coverage (MAPBIOMAS, 2019).

The preservation of competitiveness and the production capacity of this sector is strategic for Brazil. The increase in its leadership role in the next decade involves the adoption of measures in which the gains in efficiency and productivity are directly linked to a better use of natural resources.

4.2 Intensification and Technological Improvement in Agriculture and Cattle Raising

Adopting more efficient production systems, including making better use of Brazil’s natural resources and raising the technological level of agriculture can be strategic for the growth of this sector.

The adoption of these systems does not have to be expensive. In addition to vast areas with the potential to increase their agricultural production through the implementation of new technologies, Brazil has favorable edaphoclimatic[7] conditions for high agricultural productivity (ANGELKORTE, 2019; NOBRE and OLIVEIRA, 2018; PEDREIRA *et al.*, 2017).

The use of technologies for intensifying and improving agriculture is already a reality. Technologies for agricultural intensification and improvement include the no-tillage system[8] (NTS) and biological nitrogen[9] fixation (BNF). Such technologies may improve soil and water

7 Characteristics of climate, temperature, humidity, soil type, rainfall, and others that influence the development of crops, mainly vegetables.

8 It is a conservative soil management technology that aims to reduce the impacts of agriculture and agricultural machinery on the soil. This system has the characteristic of maintaining the remains of straw and plants on the soil surface to ensure coverage and protection against erosive processes.

9 Biological nitrogen fixation is a process carried out by nitrogen-fixing microorganisms in the soil that increases the availability of nitrogen compounds in the soil, assisting in the nutrition of crops.

conservation, as well as soil fertility, and reduce costs arising from the excessive use of fertilizers (a product Brazil imports), pesticides, and fossil fuels used in agricultural machinery (NOBRE and OLIVEIRA, 2018). It is estimated that these new technologies will increase crop yields by 30 to 300% (ANGELKORTE, 2019), and that they may increase income up to 3.5 times[10] (ANGELKORTE, 2019).

However, although these technological improvements are already in place in Brazil and encouraged by Brazil's Low-Carbon Agriculture Plan (ABC Plan in Portuguese), greater financial investments are needed at strategic points. This includes an increase in Rural Credit, so that producers have access to necessary equipment and inputs and to incentivize the development of qualified professionals to implement it. The greater availability of resources does not guarantee their application, they also require greater technical and managerial ability of the producer to optimize the benefits resulting from more sustainable technologies.

Brazil has excellent soil and climate conditions, as well as extensive technical knowledge for increasing production and productivity of grassland fields. This type of production improves animal nutrition, reduces the fattening time of the herd, and increases production efficiency. Less need for animal displacement and better feeding conditions could improve meat quality and production time, adding value and contributing to a more favorable trade balance (ANGELKORTE, 2019).

Such technologies make it possible to increase the quality of employed labor due to the greater complexity of some activities involving this type of agricultural production. They also increase the income of the rural producer, since it is possible to triple production on the same hectare (PEDREIRA *et al.*, 2017). However, Brazil has yet to produce or implement this cutting-edge agricultural machinery (ANGELKORTE, 2019; NOBRE *et al.*, 2018; PEDREIRA *et al.*, 2017), so the country would need to invest in technical assistance and rural extension.

Advancing the agricultural and livestock sector is undoubtedly challenging. However, the benefits outweigh the difficulties. The technological transformation must be carefully planned, so that there is no expansion of agricultural borders. Expanding agriculture farther from consumer centers and ports, or into environmental conservation areas would have negative consequences. For instance, soybean production in certain areas can decrease by up to 60%, while as a country Brazil may lose 30-34% of its area for soybean cultivation due to changes in temperature and climate caused by forest loss (OLIVEIRA *et al.*, 2013).

Another win-win situation arises from the need to improve irrigation efficiency and to preserve Brazil's water resources. Currently, there is considerable water loss due to a lack of incentives to adopt more efficient irrigation means, such as drip and micro-sprinklers. Reducing the use of chemical inputs can also avoid the contamination of precious water reserves (ANA, 2017; INSTITUTO ESCOLHAS, 2019) and minimize losses in the water distribution to the population.

Finally, it is important to consider that increasing agricultural production causes an increase in energy demand due to the higher level of mechanization or irrigation systems (ANGELKORTE, 2019). Increased agricultural productivity also requires more skilled labor to operate machinery and equipment, as well as rapid diagnostics for expeditious interventions at all stages of production. While the first challenge can be overcome only by decentralized renewable production, the second challenge can be solved with improved technical education resources.

10 However, there is a decrease in jobs caused by technology processes (PEDREIRA *et al.*, 2017).

Box 3

Challenges and incentives for the intensification of agriculture in Brazil

One of the major opportunities for fighting deforestation in Brazil is the intensification of agricultural activities. According to the Borlaug hypothesis, higher productivity per hectare could reduce the need for expansion into new agricultural areas to increase production, and could thus reduce deforestation. However, the trends observed in the stocking rates of pastures (cattle per hectare of pasture) and in the concentration of land may be associated with an increase in the already highly inefficient land of use, making efforts to intensify production even more difficult. The comparison of data from the last three Agricultural Censuses shows that, after improvements in the stocking rate between 1996 and 2006, the indicator stagnated between 2006 and 2017. In addition to stagnation at the national level, the situation is even more worrisome due to the decrease in stocking rate in the Midwest and North regions, which are the current axes of expansion of the Brazilian cattle herd (Table 1).

Table 1

Cattle and pasture stocking rates: Brazil and macroregions

	1996		2006		2017	
	Cattle herd (millions)	Stocking rate (cattle/ha)	Cattle herd (millions)	Stocking rate (cattle/ha)	Cattle herd (millions)	Stocking rate (cattle/ha)
Brazil	153.0	0.86	176.1	1.10	172.7	1.08
North	17.3	0.71	32.5	1.21	34.8	0.94
Northeast	22.8	0.71	25.8	0.84	21.7	0.95
Southeast	36.0	0.95	34.6	1.24	31.5	1.29
South	26.2	1.27	23.6	1.50	23.5	1.59
Midwest	50.8	0.81	59.6	1.00	61.1	0.95

Source: IBGE, Agricultural Census of 1996, 2006, 2017.

A second aspect to be highlighted is the strong expansion of areas of large agricultural establishments. The comparison between the last two Agricultural Censuses shows that between 2006 and 2017 there was an increase of 17.08 million hectares in establishments with more than 1,000 hectares (Table 2). This increase corresponds to 97% of the variation of total area of agricultural establishments in that period. The participation of this group increased from 45% to 47.6% in relation to total area. The average land Gini index of municipalities in the Legal Amazon remained constant: 0.69 in 2006 and 0.68 in 2017.

Table 2

Area of agricultural establishments according to Brazil's area groups (2006/2017)

Area groups	Census area 2006 (million hectares)	Census area 2016 (million hectares)	Variation (million hectares)
Total	333.7	351.3	+ 17.6
Less than 10 ha	7.8	8.0	+ 0.2
From 10 to less than 100 ha	62.9	63.8	+ 0.9
From 100 to less than 1000 ha	112.8	112.3	- 0.5
More than 1000 ha	150.1	167.2	+ 17.1

Source: IBGE, Agricultural Census, 2017.

In addition to socioeconomic impacts, the tendency towards larger farms in the region also raises concerns about effects on deforestation. The economic literature provides vast evidence of a negative relation between productivity and farm property size. Larger properties are associated with low productivity rates and require a greater amount of land to achieve a given production level. Thus, the consolidation of land in the Amazon is associated with less intensive land use and increased pressure for deforestation.

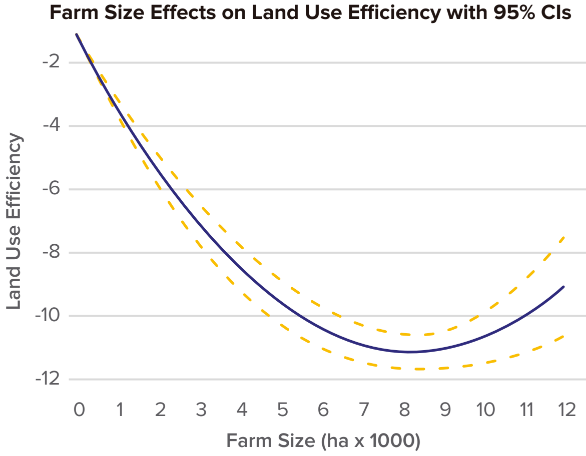
This land concentration issue is particularly critical in the Legal Amazon, where 60% of the region's agricultural land is on properties larger than 1,000 hectares. Such large properties account for 2.4% of the total number of establishments in the region. On the other hand, only 1.3% of the agricultural area is owned by establishments smaller than ten hectares. This consolidation of land in large properties has intensified over time. The comparison of data from the Agricultural Censuses allows us to observe that the percentage of establishments smaller than ten hectares in the Legal Amazon decreased from 55.2% in 1985 to 32.3% in 2006 (IBGE, 2019).

In addition to poor land use, studies suggest that agriculture in the Legal Amazon is characterized by a low level of technical efficiency in the use of production factors. Estimates indicate that agricultural establishments could increase production by approximately 30% without changing the amount of production factors. The level of inefficiency is even more critical in the specific case of land use: the establishments in the Legal Amazon could be reduced by 87% and still achieve current production levels.

The degree of resource waste is not homogeneous in relation to property size. Inefficiency varies nonlinearly, assuming a "U" shape (Figure 1). Small establishments could be relatively more efficient in land use. Efficiency would decrease with property size, but from a certain point it would increase again. However, estimates show that the point at which efficiency increases again is approximately 8,000 hectares, much larger than the size of a typical property in the Legal Amazon. That is, the inefficiency of land use in this region almost always increases with property size (FERREIRA and FÉRES, 2020).

Figure 1

Estimated relation between property size and land use efficiency



Source: Ferreira and Féres, 2020.

The negative relation between property size and land use efficiency suggests that the tendency to concentrate property in the Legal Amazon may be a force against efforts to intensify agricultural activities in the region. It is necessary to think of measures that reduce inefficient land use in agricultural establishments in general and particularly in large properties.

Measures and technologies aiming to reduce inefficiencies in the agricultural sector are already well documented. The restoration of degraded pastures could allow the most efficient land use, as well as the expansion of the no-tillage system. The adoption of these practices can be a "win-win" strategy. In addition to environmental benefits resulting from the reduction in deforestation, many of these technologies could also increase productivity and profitability of agricultural activities. Notably, Brazil already has credit lines provided for in the ABC Plan that offer low-cost financing to farmers interested in implementing sustainable agriculture projects.

Despite the recognition of benefits associated with intensification technologies and credit availability, the demand for credit associated with pastures is low. The important issue is not the existence of technologies available for intensification, but how to generate incentives for their adoption and how farmers can adopt more sustainable farming practices.

4.3 The Role of Economic Incentives in Improving Agricultural Productivity

There is a solid body of scientific evidence supporting methods for increasing productivity while conserving natural capital, and it is crucial to translate that evidence into changed behavior at the farm level.

The reformulation of the agricultural credit program (which aims to direct subsidies to farmers who invest in sustainable practices) could be an effective mechanism to encourage the intensification of agricultural activities, achieving impact at the needed scale.

A comparison between the average interest rate of the Crop Plan, a business-as-usual line of credit, with those offered by the ABC Plan, which promotes changes in behavior, shows that the difference is relatively low. The low interest rate difference, coupled with high transaction costs involved in disbursing the ABC Plan discourage farmers from taking credit for investment in sustainable practices. Subsidies must be conditioned to the environmental performance of agricultural establishments and should be focused on those who actually produce positive environmental externalities. The current scenario has few financial incentives for the intensification of agriculture.

Similarly, it is also necessary to reconcile tax instruments with the objectives of environmental legislation. In particular, the Rural Land Tax (RLT) has not succeeded in achieving its extra fiscal purposes to induce increased productivity and discourage land speculation. The inefficiency of RLT is especially important in the Amazon, where deforestation of public lands and maintenance of unproductive properties are common practices used to later sell land. The inefficiency of RLT is also associated with the low value of the tax. In 2012, this value was around US$ 0.40 (R$ 2.00) per hectare.

Much of the low RLT collection is associated with the self-declaratory nature in the calculation of the tax and with difficulties in its supervision. By filling in data to calculate the tax amount, the rural owner has incentives not to disclose exact information. Specifically, there are incentives to undervalue the market value of bare land, overestimate the non-taxable area (of environmental interest) of the property, and overestimate the use of usable areas. Supervision has been extremely inefficient in curbing these distortions. Even the parameter with the simplest inspection - value of bare land - is not properly evaluated by the Internal Revenue Service (IRS). The absence of a comprehensive register of georeferenced properties is one of the main factors for the precarious supervision of information provided by the owners (IMAZON, 2015).

In addition to the problems in determining and supervising the RLT, there are problems in the instrument design itself that affect its potential as an induction mechanism to increase agricultural productivity. RLT legislation requires minimum productivity rates only for livestock and the extraction of some forest products. The benchmarks for livestock productivity are outdated. The minimum productivity rates in the Amazon were based on the Agricultural Census of 1975 and are extremely low. In 82% of the Amazon, the minimum productivity index for livestock to be considered productive is only 0.5 cattle/hectare (IMAZON, 2015).

The reformulation of the RLT to reconcile it with environmental objectives involves the recovery of the extra-fiscal purpose of this tax. This tax must recover its purpose as an instrument of induction to productivity gains and consequently to intensification of agriculture.

Several actions can be carried out in this sense. The georeferenced databases available in Brazil – such as a map of properties of the Rural Environmental Registry (BRASIL, 2012a) or the TerraClass Land Cover (BRASIL, 2010a) – could be used to verify owners' declarations. It would also be important to update the minimum productivity indexes, bringing them closer to numbers more compatible with available technologies. The increased cost of land reclassified as unproductive could provide incentives for a transfer of these lands to the most efficient producers via lease or sale.

In summary, there is ample space for use of credit policy and tax policy instruments as mechanisms of economic incentive towards intensification of Brazilian agriculture. The path involves the reformulation of these mechanisms to reconcile them with environmental objectives, strengthening a new culture that values greater resource efficiency.

4.4 Pasture Recovery

Studies of livestock and pasture degradation prove that greater efficiency could be a market opportunity for this sector and increase productivity in the short term, in addition to increasing jobs and income in the field. EMBRAPA estimates that Brazil has about 200 million hectares of pastures, of which 75% have some degree of degradation and at least 50 million produce half of their potential (EMBRAPA, 2019). However, this diagnosis is not necessarily recognized by cattle ranchers, as many do not perceive that their areas have some degree of degradation. In other words, a great challenge of this sector is not necessarily related to the lack of technology available, but to the lack of access to technical assistance.

According to the 2017 Agricultural Census, only 12 million hectares of pasture land were declared as degraded by cattle ranchers (IBGE, 2019). The discrepancy between the perception and analysis of experts from EMBRAPA and the perception of cattle ranchers reinforces the lack of adequate Technical Assistance and Rural Extension (ATER). Of every four hectares destined for livestock in Brazil, three of them do not have ATER (IBGE, 2019).

This has negative consequences, as raising cattle in poor areas worsens degradation. In fact, in the last ten years, according to the IBGE, the area of planted pastures in Brazil has grown by 8%, while degraded pasture lands increased by 20%, signaling a continued expansion of new areas and a loss of productivity.

A recent study estimated that Brazil could double its agricultural production by exploring existing opportunities to increase productivity (ASSUNÇÃO *et al.*, 2018) and by following the technological trends used by many developed countries. But compared to countries of the Organization for Economic Co-operation and Development (OECD), the share of total agricultural spending destined for innovation and increased productivity in Brazil is still low.

Finally, it is important to emphasize that it will be necessary to increase the dissemination of knowledge and financing for producers to significantly expand agricultural production through productivity gains and recovery of pastures. Even if the investment required to reverse degradation is high, the return on investment is certain (Box 4).

Box 4

Rural Credit

Data from the Central Bank shows that, in the last decade, rural loans have financed on average only US$ 2.35/hectare (R$12.29/hectare) of pasture per year. Even considering a pasture renewal cycle, also known as rotation, of five years, the average credit value for investment in fertilization, correction, and soil protection, as well as formation, reform, and recovery of pastures, did not reach US$11.70/ hectare (R$61.50/hectare). This is 30 times lower than EMBRAPA's investment recommendation. Due to the lack of investment, ranchers lose an equivalent of US$1.40-2.40 billion (R$7.3-12.4 billion) per year in revenues, which represents 9 to 15% of the gross value of beef cattle production (BACEN, 2019).

The investment required to reverse degradation is high, but worth it. The investment would be approximately US$400/hectare (R$2,100/hectare), or around US$5 billion (R$25 billion) to recover the critical 12 million hectares identified in the 2017 census. Even so, previous unpublished data (contained here) estimates that this investment, when applied over ten years with a discount rate of 8.5% yr., would generate an NPV of US$3.6 billion (R$19 billion) in 6.58 years of payback and an additional payment of US$142 million (R$ 742 million) in taxes. This is a clear signal to producers, investors and the government that investing recovery of degraded pastures is, indeed, a good deal.

Brazil already has credit programs, such as the ABC Plan, which provides low-cost credit to farmers who implement sustainable farming practices to improve pastures, increase producer income, and curb degradation of production factors. However, the financing of the ABC Plan under the Federal Agricultural and Livestock Plan 2018/2019 was only US$191 million (R$1 billion), while the 2019/2020 Safra Plan provided for US$43.07 billion (R$225.59 billion) (MAPA, 2019). The Safra Plan also provides credit to farmers, and is launched on an annual basis. It could thus play a much broader role as the main financing agent of investments to boost more sustainable livestock. It is important to note, for example, that between 2013 and 2018 other programs have funded an additional US$4.7 billion (R$8.8 billion) for pastures. It is not possible to specify whether they have been applied to recover degraded pastures and increase productivity.

Therefore, it is important to promote further incentives such as:

a. **An increase in credit limit for pasture recovery:** this could be allocated to farmers who comply with environmental legislation, as they offer lower risk of decapitalization since the need for investments in native vegetation recovery is currently absent from their planning horizon.

b. **An increase in the limit of ATER expenses:** currently, depending on the credit line, the limit for an item (rubric) on technical assistance ranges from 1 to 6%. An increase in the limit of Technical Assistance and Rural Extension could apply to resources from rural credit for the recovery of degraded pastures. Other credit lines, such as the ABC program, which does not identify percentages, could serve as the basis for the entire Safra Plan.

c. **A proportional reduction in the risk factor:** this could be best applied to subsidized insurance for livestock in degraded pasture areas to be recovered and would be based on the expected additional revenue. It would presumably be higher since they are at the lower limit of support capacity.

d. **Reorientation of rural credit investments:** It is expected that subsidized resources should subsidize changes in the production process and not the maintenance of current operations.

The ambiguous role of rural credit – a trade-off between increased areaor productivity – can be effectively minimized by legal constraints that guide the application of the resource to optimize production or curb illegal horizontal expansion through command and control mechanisms.

An example is the positive effect of the Normative Resolution nº. 3545, issued in 2008 by the Central Bank (BACEN, 2008), which conditioned subsidized credit in the Amazon to compliance with land regularization and the Forest Code. Statistical models show that in places where this BACEN decree is in force, there is less deforestation and no decrease in production (ASSUNÇÃO *et al.*, 2020).

4.5 Recovery of Forests and Degraded Areas

Investing in the recovery of forests and degraded areas in Brazil leads to economic gains and environmental and social benefits. The development of the brazilian forestry sector economy with large-scale planting of native species has the potential to consolidate the country's international commitments and attract public and private investments, while also generating business with developed countries through carbon credit markets.

Not only does reforestation remove carbon by increasing the biomass of forests, it also reduces emissions from deforestation and degradation of forests and degraded soils. This investment would improve the economy of the rural sector through new jobs and income and the development of the local bioeconomy.

To guide decision-making policies aimed at such a recovery, WRI Brasil developed the Economic Valuation of Restoration with Native Species (VERENA) (Box 5). Initially, the project mapped more than 35 case studies of reforestation with native tree species and agroforestry systems (AFSs) in different Brazilian regions and conducted financing modeling in 12 of those cases (WRI BRASIL, 2017).

Box 5

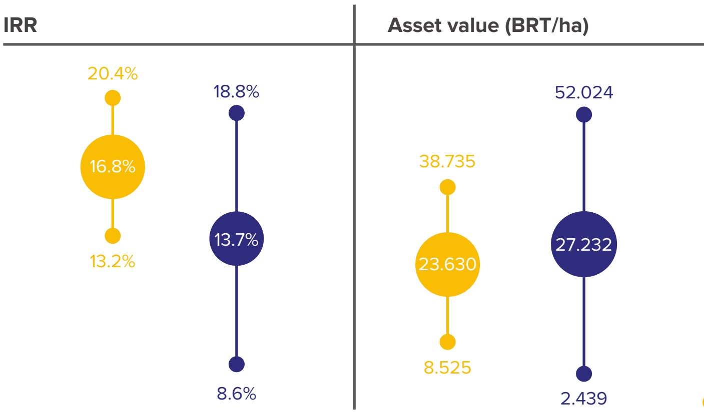
VERENA Project

Native Brazilian tree species have existed for thousands of years. They have already led to successful commercial experiences, but there was no history of this asset from the point of view of capital market. The VERENA project analyzed the history of more than 100 years of risk and return of various asset classes and publicly traded companies in the global capital market. Above all, VERENA gathered information on how these various asset classes correlated with each other, the economy, and inflation. It then applied the same methodology for the analysis of native Brazilian tree species as internationally traded assets.

Figure 2 shows the Internal Rate of Return (IRR) and the Net Present Value (NPV) of VERENA assets of the 12 case studies compared to those in the agriculture and forestry sectors.

Figure 2

VERENA's Internal Rate of Return (IRR) and Net Present Value (NPV)



Agriculture and Silviculture assets	Source
Eucalyptus 1	Company 1 - 2017
Eucalyptus 2	Company 2 - 2017
Eucalyptus 3	Fnp Agrianual - 2017
Banana	Fnp Agrianual - 2017
Cocoa	Fnp Agrianual - 2017
Coffee	Fnp Agrianual - 2017
Lemon	Fnp Agrianual - 2017
Pupunha	Fnp Agrianual - 2017
Manioc	Fnp Agrianual - 2017

● VERENA ● Agriculture / Silviculture

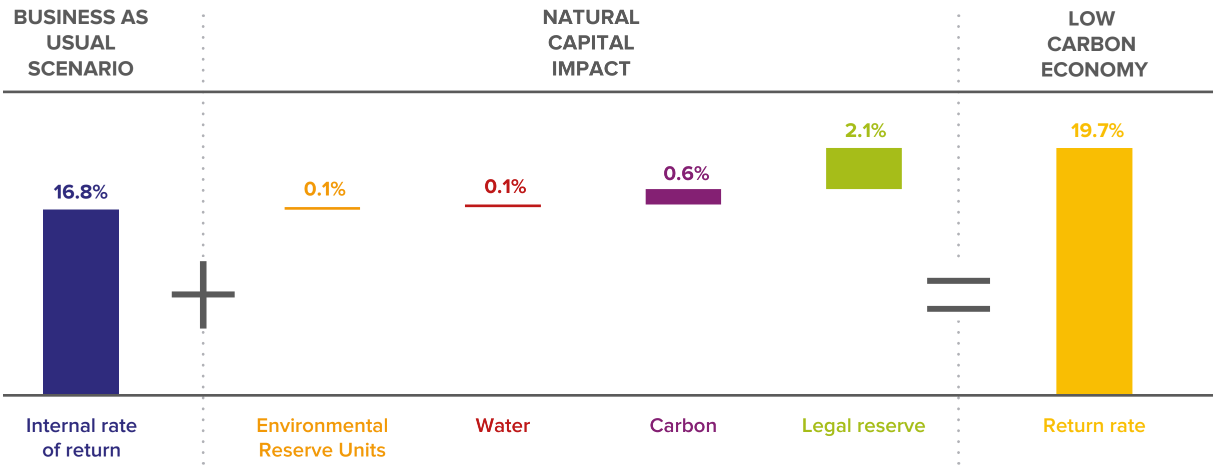
Source: Batista, 2018.

Assets composed of native wood species consider the real appreciation of the price of wood. The upper and lower ranges comprise the standard deviation with 95% confidence.Reforestation with native species and agroforestry systems presents a 12% of internal rate of return (ITR), similar to eucalyptus and permant crops. The returns assessed in the 12 cases of VERENA are comparable to the traditional sectors of modern agriculture and forestry. Although there is no statistical difference between cash requirements and financial returns upon comparing asset classes, these variables are expected to be higher for AFS and reforestation with native species due to a greater use of labor in AFS and a longer harvest cycle of native tree species. The analyses and the results of the 12 case studies in the economic modeling confirmed that it is advisable to invest in reforestation with native species and agroforestry systems.

Figure 3 presents a scenario with the impact different externalities on the internal rate of return on the VERENA case studies. Despite the marginal increase in the internal rate of return, investing in reforestation with native species and AFS has the potential to generate several positive externalities and make the business more attractive to potential investors and producers.

Figure 3

Impacts of natural capital on the IRR of case studies



Source: Batista, 2018.

As the VERENA project shows, investments in forests have a low correlation with macroeconomic development and a high correlation with inflation (BATISTA, 2018). Both aspects offer risk diversification by including reforestation in the investments portfolio. An important conclusion of such an analysis is that first-generation genetic improvement gains in productivity can be up to 25%, which would be enough to further enhance the attractiveness of reforestation with native species and its impacts on climate change mitigation. Therefore, it is essential to invest in research and development to increase attractiveness and reduce the risk perception of native species and SAFs ventures.

To address knowledge gaps related to native species and make the business even more attractive to investors and producers, the Brazilian Coalition on Climate, Forests and Agriculture prioritized the development of a research and development platform for native species. This platform will involve leading public and private universities and research institutions with knowledge on forestry, as well as forestry companies and the government. Recent studies also point out the urgent need to develop new commercially applicable technologies to improve the productivity and performance of the main Brazilian native tree species (ROLIM *et al.*, 2019).

4.6 An Assessment of Crop-Livestock-Forest Integration Systems (ILPF)

Crop-livestock-forest integration (ILPF) is a production strategy that integrates production in agricultural, livestock, and forestry systems in the same area or promotes planned rotations to optimize land use. It can be done intercropped, in succession, or in rotation. The benefits are mutual for all activities. This form of integrated system seeks to optimize land use, increase productivity, diversify production, and generate quality products.

In terms of competitive advantages and institutional compatibility, ILPF is a Brazilian technology. It has different modalities, adopted at different levels of intensity (EMBRAPA, 2015). The ILPF system is one of the agricultural technologies the ABC Plan encourages to stimulate sustainability and rural profitability.

Co-benefits such as decreased contamination of rivers by chemical inputs compared to conventional production models, increased water infiltration in the soil, and increased local biodiversity are characteristic of these systems (FRANCHNI *et al.*, 2018). In addition, it has a high atmospheric carbon capture potential from the growth of planted and native forests through direct storage in soils (NOBRE and OLIVEIRA, 2018; SANTOS, 2016).

Integrated systems are already a reality in Brazil. Currently, there are more than 15 million hectares that have obtained high levels of productivity and profit for rural producers (ASSAD *et al.*, 2019a). However, the lack of high-skilled labor and the need for assistance programs for the implementation phase of these systems are still bottlenecks that must be overcome (FRANCHNI, 2018). The large-scale implementation of these agricultural techniques requires high investments, which are generally recovered over the medium to long term (ASSAD *et al.*, 2019b).

Box 6

The role of technological innovation and the bioeconomy in Brazil

Brazil's transition to a new, sustainable economy involves the production and use of innovative materials that guarantee better performance and use renewable natural resources and national labor while reducing environmental impacts. Global trends suggest that the world is investing in rapid development of information technologies and other innovations that can profoundly change business models and trade flows (CNI, 2017a).

The concepts of "Industry 4.0" and the 21st century economy reinforce the importance of developing a bioeconomy based on biological and biomimetic assets to develop Brazil (NOBRE, 2019). With the largest plant biodiversity in the world, Brazil has about 50,000 plant species, of which at least 20,000 are endemic. Most of them are in the Amazon, Cerrado, and Atlantic Forest biomes (FLORA DO BRASIL, 2020).

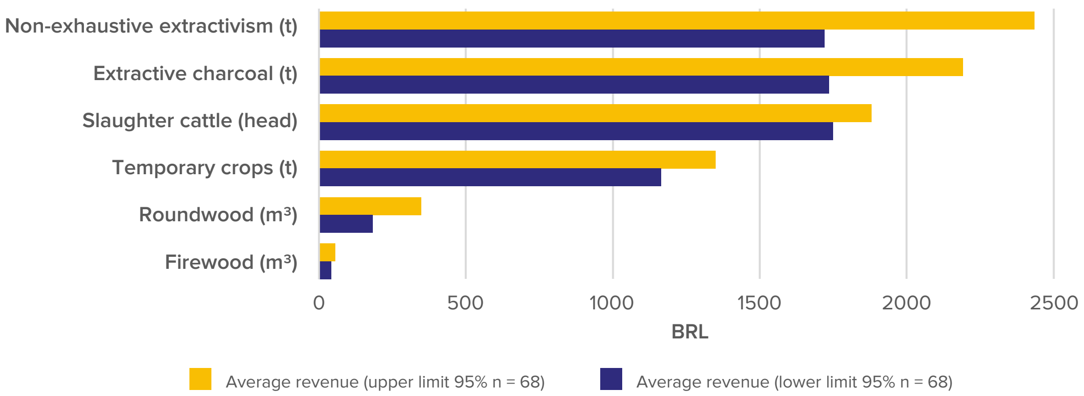
Economic use and valorization of this biodiversity has been expanding due to demand from the international market. An emblematic case is açaí, the production of which grew 92% in the last decade. Such practices can lead to an economy generated by non-exhaustive extraction.

This can drive a much larger economy. Non-exhaustive extraction is a system that supports the collection of seeds, flowers, fruits, or leaves, but in which plants are not completely removed. This method has increased the production of açaí by 45% in the last ten years, while the value of production increased, in real terms, by 68%, or R$1.6 billion in 2018 (authors' calculation using IBGE data, 2019a, 2019b, 2019c).

Although all Brazilian regions and their biomes are fully capable of developing an economy based on biodiversity – the so-called bioeconomy - the Amazon region offers the best conditions for immediate investments. The Amazon already has a large bioeconomy. It accounts for no less than 74% of non-exhaustive extraction activity (authors' calculation using IBGE data, 2019a, 2019b, 2019c). To demonstrate this biocapacity, this document presents a brief study using the latest census data (Figure 4). For the 68 immediate geographic regions in the Amazon biome (former microregions), revenues generated by the main activities carried out in rural establishments were estimated.

Figure 4

Potential revenue generated



Source: Prepared by the authors.

The results show that the non-exhaustive extraction activity, which includes 37 items from 31 native plant groups, generates an average revenue of between US$334-470 per ton (R$1,750 and R$2,460 per ton), making it extremely competitive. The average revenue (within its minimum range) is identical to that of charcoal and cattle raising, and higher than temporary (indiscriminate) logging and firewood harvesting. At the upper limit, the average revenue from non-exhaustive extraction is almost twice that of temporary crops and 30% higher than that of cattle raising (authors' calculation using IBGE data, 2019a, 2019b, 2019c).

5

SOCIOECONOMIC BENEFITS OF A NEW ECONOMY FOR BRAZIL

The measures and actions discussed in the previous sections of this study can boost the Brazilian economy by taking advantage of the country's potential and competitive advantages, while simultaneously seeking socio-environmental benefits. This section presents the results of a modeling exercise to quantify the socioeconomic benefits of applying similar measures economy-wide – that is for a "New Economy for Brazil".

The potential of these measures to foster Brazil's economic growth was estimated through interactive modeling. This modeling is based on the interaction between Brazilian Land Use and Energy Systems (BLUES) and the Green Economy Model (GEM).

The BLUES model was run to quantify effects in terms of energy use, GHG emissions, and land use. The results, in turn, feed the GEM, which estimates the co-benefits in terms of productivity gains, economic growth, jobs, GHG emissions, and environmental pressures. A brief explanation of the models is provided in Box 7 below. The method is detailed in Appendix A.

Three scenarios with increasing degrees of penetration of measures for a new economy have been created using the GEM-Brazil:

I. **Business-as-usual (BAU):** A continuation of current business-as-usual trends, including a slowly declining GDP growth rate, growing GHG emissions, and slightly increasing unemployment.

II. **New Economy for Brazil (NEB):** A series of low-carbon actions as identified in this Report, including hybrid vehicles, electric vehicles, gasoline vehicles, greater use of charcoal in the iron and steel sector, and systems of high agricultural and pasture productivity.

III. **NEB +:** A scenario similar to NEB, in which half of land currently used could be "compensated for" by (1) reducing food loss and still maintaining the same level of agricultural production as that of BAU, (2) a higher productivity of crops or livestock along the lines of opportunities identified in Section 4 of this study, and (3) half the use of land use for forest restoration and for reducing illegal deforestation.

Box 7

Methodological note – description of the models

Brazilian Land-Use and Energy Systems model (BLUES)

BLUES is an optimization model for Brazil. It was built on the MESSAGE model generation platform (Model for Energy Supply Strategy Alternatives and their General Environmental Impacts). The platform was designed to develop and evaluate energy supply alternatives considering constraints such as investment restrictions, fuel prices and availability, environmental regulations, market penetration rates for new technologies, among others.

BLUES is an extension of the MESSAGE-Brazil model. It was substantially updated and detailed to evaluate issues related to the Brazilian reality. Its scope was expanded to consider the land use sector (KOBERLE *et al.*, 2015). The energy system is detailed in transformation, transportation, and energy consumption sectors. More than 1,500 technologies are customized for each of the model's six native regions. The representation of land use includes forests, savannas, low- and high-capacity pastures, integrated crop–livestock–forestry systems, arable land, "off-season crops" (the period in-between the soil preparation for planting until the harvest), planted forests, and protected areas. The model minimizes the costs of the entire energy system, including electricity generation, agriculture, industry, transportation, and construction sectors, which are subject to restrictions that represent real-world situations for the full range of variables considered.

Green Economy Model (GEM)

GEM (detailed in Appendix A) was designed to assess policy outcomes across sectors, economic actors, dimensions of development over time. It expands upon policy analysis carried out with sectoral tools by accounting for the dynamic interplay between economic sectors, as well as social, economic, and environmental dimensions of development (Bassi, 2015). The GEM is built using the system dynamics (SD) methodology. It serves primarily as a knowledge integrator. SD is a form of computer simulation modeling designed to facilitate a comprehensive approach to development planning in the medium to long term (MEADOWS, 1980; RANDERS, 1980; RICHARDSON and PUGH; 1981; FORRESTER, 2002). SD operates by simulating differential equations with "what if" scenarios explicitly representing stocks and flows. It can integrate optimization and econometrics. The purpose of SD is not to make precise predictions of the future, or to optimize performance; rather, these models are used to inform policy formulation, forecast policy outcomes (both desirable and undesirable), and lead to the creation of a resilient and well-balanced strategy (ROBERTS *et al.*, 1983; PROBST and BASSI, 2014).

The GEM considers different types of capital, built or physical, i.e., social, human, and natural. Infrastructure is part of built capital. In the case of natural infrastructure, it is included in natural capital. Some types of infrastructure are analyzed in detail, such as when they are part of a focus sector, while others are grouped into public and private investments. The model uses inventories and flows. Infrastructure capacity is represented by a stock. Investment increases inventory, and withdrawal of investment reduces it. Each macro sector (e.g., agriculture, industry, and services) has a capital stock that represents all types of relevant infrastructure needed for value adding, such as machinery and buildings. The model also includes infrastructure for utilities, e.g., roads, power generation, education, medical care, and wastewater treatment. These are types of infrastructure that do not directly affect production, but that do so indirectly.

As a result, the model considers infrastructure for public services as one of the elements that affects the total factor productivity (TFP). Together with capital and labor, the TFP determines GDP. The GEM expands the boundaries of standard, orthodox, structural economic models by enabling users to ascertain the extent to which natural capital and other forms of built capital, not considered in those models, determine and are affected by socio-economic activities under alternative policy frameworks.

In addition, the GEM can incorporate the externalities impacts associated with more sustainable policies (or their absence). Considering the challenges involved in establishing values to externalities, such as air pollution and the availability of environmental goods and services, the GEM incorporates metrics associated with pricing them, in addition to their impacts on productive factors and the effects of feedback on the system.

A series of sustainable actions identified in this study was simulated using the BLUES model, including ethanol hybrid vehicles, electric vehicles, electric buses, fuel cell trucks, biofuel, energy efficiency, greater use of charcoal in the production of iron and steel, energy generation from solar power, and agricultural and pasture systems with high productivity.

The simulation results point to a lower use of primary energy, mainly of fossil fuels, in the NEB scenarios. The electricity generation matrix also becomes more renewable, with no significant impacts on electricity prices. Advanced biofuels are an opportunity to gain market share inelastic to demand and to avoid competition with light electric vehicles.

The BLUES model devises low rates of deforestation in the BAU and NEB scenarios. In the BAU scenario, the average annual deforestation in Brazil is 3,500 km^2 (compared to 3,300 km^2 in the NEB scenario), well below the lowest historical annual rate recorded only in the Amazon (4,500 km^2 in 2012). As a way of optimizing costs, deforestation in BLUES is driven by (i) the search for high-productivity, low-cost land, or (ii) the need to expand productive land by converting the natural land cover (forest or savanna) to meet the food and energy demands. The results found that deforestation was driven mainly by the first effect.

Thus, the model shows that the growth in demand can be met without the need for deforestation while still minimizing costs. The BLUES model does not include other factors that cause deforestation (for example, illegality, capacity to enforce the law, land appropriation etc.), which indicates that these factors drive real deforestation and not necessarily the market demand for food and energy.

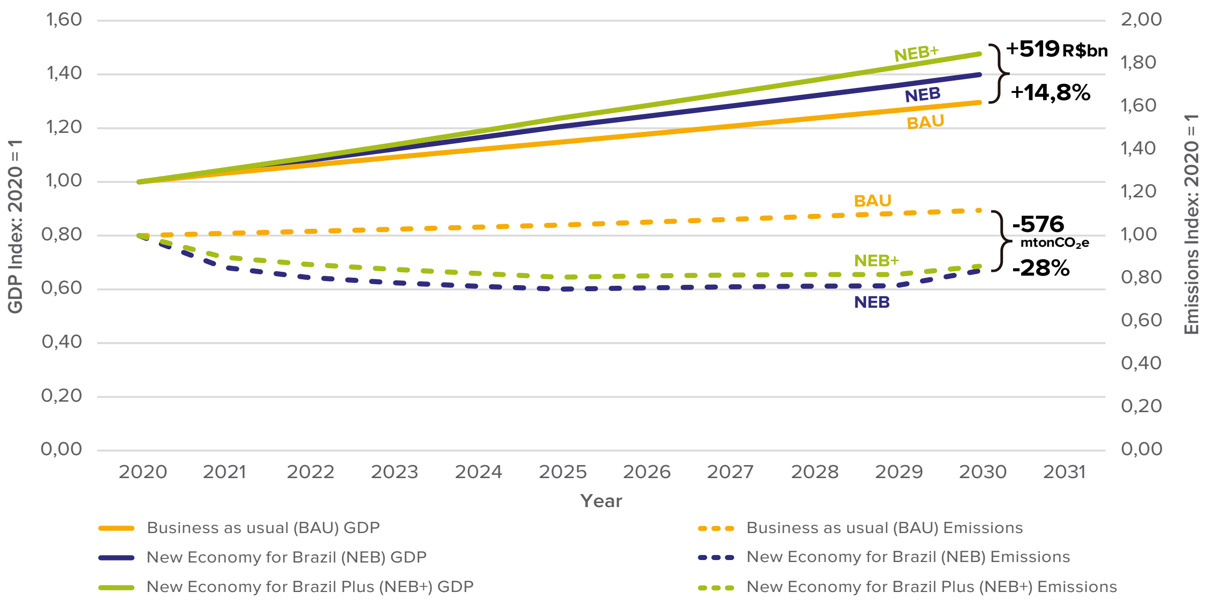
The modeling results (Figure 5) show that Brazil can obtain cumulative economic benefits of US$535 billion (R$2.8 trillion) in GDP value up to 2030, i.e., double the savings obtained by the social welfare reform approved in 2019.

These savings could be leveraged by smart and green investments, leading to reduced costs and increased productivity and efficiency. The NEB and NEB+ scenarios show net benefits through social, economic, and environmental indicators. For example, in the NEB+ scenario, in 2030 two million additional jobs could be generated compared to the BAU scenario. Better economic results under the NEB and NEB+ scenarios could still be possible with the implementation of additional sustainable policies. This empirically corroborates the fact that there are no trade-offs associated with these policies.

The NEB+ scenario could, for example, lead to higher agricultural production and greater GDP than the BAU scenario. In addition, by increasing productivity on some lands, this scenario could result in reduced pressures for converting land for agriculture, reducing deforestation and, therefore, reducing GHG emissions related to land use. These results reflect the integration of different research and policy formulations and can be improved based on input from more experts and stakeholders using a multi-stakeholder approach to refine the model and co-create the analysis.

Figure 5

GDP growth and CO_2e reduction in the NEB and NEB + scenarios



Source: Prepared by the authors.

The NEB and NEB+ scenarios outline potential benefits of a set of policies that focus on a growth trajectory, increased productivity and competition, and preservation of natural capital and the environment. This trajectory includes:

- Increased investment in quality infrastructure;
- Increased efficiency in the industry sector, capitalizing sectors in which Brazil has natural advantages;
- A green agricultural strategy focused on enhancing productivity and competitiveness;
- Expansion of access to new finances, markets, and consumers through sustainable products and production processes.

These are some of the main opportunities that Brazil could prioritize to improve its economic trajectory, increase the well-being of its population, and preserve its rich environment. In addition to these socioeconomic benefits, opting for this approach may improve Brazil's stance on two additional fronts: trade and the capacity to mobilize resources and attract private investments and financing needed to implement low-carbon, resilient projects.

6

OPPORTUNITIES FOR TRADE AND ACCESS TO FINANCING

A survey of natural capital accounting and sovereign debt issuance in Brazil (PINZÓN *et al.*, 2020) points out that the Central Bank, as an issuer of sovereign bonds, will face monumental challenges due to the social, economic, and environmental impacts of climate change.

On the one hand, Brazil actively manages its natural capital and strengthens the environmental component of its sovereign bonds. On the other hand, some necessary measures are not taken, and vulnerability to natural disasters drastically increases market risk. This Study reinforces the need for action by the Central Bank of Brazil, credit agencies, institutional investors, and civil society in the interest of a more resilient, sustainable future pathway for Brazil.

Natural capital accounting and the creation of science-based targets for nature are emerging as important new tools to advance the transition to green growth. With an effective accounting of natural capital, Brazil could benefit from significant opportunities arising from the global trend towards a more sustainable economy. This could be accomplished, for example, through international payments by way of carbon pricing (Box 8). These elements will be increasingly valued by investors in sovereign bonds and risks will be incorporated into prices.

This section presents a discussion on these advantages and emphasizes international trade and access to long-term financing.

6.1 International Trade and Agriculture

Globally, consumers are becoming more aware of the impacts their purchases exert on the environment. Public concern about the origin of agricultural and livestock products and the potential links to illegal deforestation have relevant consequences on demand. This concern ranges from the 2006 soybean moratorium to the 2019 threat, and in some cases implementation, of boycotts of Brazilian products that are associated with the increase in deforestation of the Amazon biome. The latter occurred in response to an increase of nearly 30% in deforestation from 2018, one of the highest rates in the last decade. Due to the recent increase in deforestation rates, 230 investors representing US$16.2 trillion (R$85 trillion) in assets expressed grave concerns about the state of the Amazon rainforest (DTN, 2019). Scientific and historical findings show that measures to control illegal deforestation do not harm agricultural productivity or economic growth (VIANNA and YOUNG, 2015; ASSUNÇÃO *et al.*, 2018)[11].

The net benefits of sustainable and deforestation-free practices for ranchers in Brazil can range from US$18 million to US$34 million (between 12% and 23% of revenue) in net present value (NPV) over the next ten years. For meat processing plants the benefit varies between US$ 20 million and US$120 million and for and retailers the benefits are between US$ 13 million and US$62 million (HARVARD, 2017).

11 The expansion of sugarcane in Mato Grosso do Sul (MS), for example, led to a peak in productivity and reduced deforestation (ASSUNÇÃO *et al.*, 2016). Between 2005 and 2012, large private investors invested in sugarcane mills, mostly in pasture areas. The expansion created positive co-benefits for agriculture. It mainly increased grain yields of soybeans and corn and positively influenced other economic sectors. Three years later, the results show that there was a 30% increase in local GDP, a 40% increase in employment, a 44% increase in wages, and a 31% increase in tax revenue. Investments in sugarcane mills also attracted suppliers of agricultural inputs and services, a more qualified workforce, and a greater supply of rural credit, which may have benefited all local agricultural producers. In addition, there were positive environmental impacts. It is estimated that the sites that received the new plants reduced deforestation by an average of 6,300 hectares (ANTONACCIO *et al.*, 2018).

Studies indicate that the incorporation of sustainability leads to better financial performance through factors such as innovation, operational efficiency, risk reduction, reduced capital cost, customer and supplier loyalty, better marketing, and higher sales.

In addition to adjusting to medium-term trends of international markets, a transition to a greener agricultural sector could protect Brazil from the negative impacts of recent changes in the global economy.

Brazil has a remarkable opportunity to access competitiveness gains in niches favorable to the country.

In doing so, Brazil can expand its commercial insertion in an increasingly complex scenario of international trade, taking advantage of opportunities to gain competitiveness in specific sectors for the Brazilian economy.

As previously discussed, accessing competitive advantages depends on encouraging the intensification and technological improvement of crop management and agricultural pastures and the implementation of integrated systems (crop-livestock-forest integration, ILPF). This can ensure sustainability and competitiveness with the main international agricultural suppliers. Otherwise, a significant part of Brazilian agricultural commodity markets, notably the European Union, could further restrict products that directly or indirectly come from unsustainable production chains. This also seems to be gradually the case with China. As Brazil's largest trading partner since 2009, China's cross-border trade with Brazil reached more than US$100 billion (R$524 billion) in 2018. The vast majority of this trade is Brazilian exports, accounting for almost US$67 billion (R$351 billion) (BRASIL, 2019).

In addition, Brazil can further capitalize on international financial trends that provide low-cost capital for sustainable ventures. There are many opportunities emerging from current trends in trade and finance, as detailed in the next section.

6.2 Pathways for Alternative Funding Sources

Mobilizing resources to promote long-term projects is still seen as a challenge, but this situation is changing rapidly. Globally, sustainable investment assets have stood at US$30.7 trillion (R$ 161 trillion), i.e., a 34% increase over two years. They already account for more than 50% of the total assets professionally managed in Canada, Australia and New Zealand, almost half of Europe, 26% of the United States, and 18% of Japan (GSI, 2018). Latin America, including Brazil, lags behind in the growth of sustainable assets.

There are also significant signs of increasing financing opportunities for investments that lead to lower carbon emissions. For example, investors are moving away from fossil fuels.

Recently, the European Investment Bank (EIB), which funds US$17 billion (R$89 billion) in energy finance each year, has committed to stop investments in fossil fuels at the end of 2021. Similarly, the Norwegian Sovereign Wealth Fund, the largest in the world, with US$1 trillion (R$5.24 trillion) in assets built on oil and gas revenues, is shifting away from investments in oil and gas for financial reasons. At the same time, China's domestic green bond market has expanded rapidly with the total issuance of US$60.9 billion (R$318.95 billion) as of October 2018. The trend is clear. The poorly subscribed auction of Brazil's offshore pre-salt oil fields near the environmental reserve of Abrolhos in Bahia was a recent signal of a growing reluctance to invest in long-term fossil fuel assets in the country.

The integration of sustainability criteria into Brazil's project portfolio could allow it to attract necessary finances to fill its long-term financing gap. This opportunity will become more prominent in the coming years. Organizations such as the Institutional Investors Group on Climate Change, which counts more than 200 investors in 14 countries with more than US$32.6 trillion in management assets, are mobilizing capital for a low-carbon transition aiming to ensure resilience to impacts of climate change (IIGCC, 2020). Along the same lines, the BlackRock investment fund issued a statement to investors stating the importance of environmental, social, and governance (ESG) criteria to understand risks and measure return associated with investment in fixed income, multi-assets, equity, and other assets (BLACKROCK, 2019).

6.3 Trends in the National Financial Market

In Brazil, a trend has emerged in expanding the financing of sustainable projects. Credit from Brazilian private banks for such projects is increasing rapidly and has enormous growth potential, as a series of studies of the National Federation of Industries has indicated (FEBRABAN, 2019). In fact, FEBRABAN has consistently provided guidance, backed by international best practices, on how to accelerate this trend. In an environment where basic interest rates are decreasing, as is the case of Brazil, the potential growth of green financial tools is significant, and it should be considered appropriately by relevant stakeholders.

The National Bank for Economic and Social Development (BNDES) plays a notable role in promoting innovative green financial instruments.

Historically, BNDES has been a direct funder of sustainable projects (STUDART and RAMOS, 2019) and a leading issuer of green bonds. Currently, BNDES is one of the few public institutions that can play a leading role in promoting efforts to increase private investment in quality infrastructure. This would require BNDES to continue investing in project development. BNDES should also continue its policy of developing new instruments that can leverage additional resources from private banks which could eventually create a bridge between infrastructure developers and institutional investors.

Another stakeholder group that could benefit from these trends are producers. By promoting sustainable supply chains, producer access to cheaper finance will increase. In the case of agriculture, for example, the use of BNDES credit lines already increases the producers' marginal internal rate of return (IRR) by about 2%. Similar options for credit lines from private financiers are expanding. For instance, Santander, Bunge, and The Nature Conservancy (TNC) already offer credit conditions that increase the IRR by almost 1% in the States of Maranhão, Tocantins, Piauí and Bahia (MATOPIBA) and 0.8% in the Southern Cerrado region (TNC, 2019). IRR can also increase through mechanisms such as direct payments for ecosystem services.

Sustainable agriculture could also directly benefit from these trends. Agricultural financing still depends largely on public institutions such as BNDES and other banks that act as commercial banks or as development banks, such as CAIXA and Banco do Brasil. However, the potential of multilateral and private financing has been increasing significantly in recent years. In fact, in a country with a high stock of natural resources and biodiversity, opportunities for financing infrastructure and agriculture are more often associated with sustainable economic development than with business-as-usual. This is the case in both multilateral (IDB, GEF/UNEP, GCF, CAF, IFC) and bilateral (Germany/KfW) channels.

6.4 Green Bond Markets

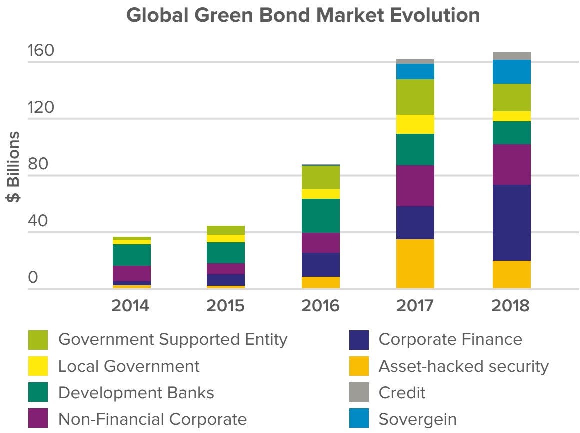
Governments anticipate that the trend of expanding financing for sustainable projects will reap increased benefits. Brazil can access sorely needed and substantial benefits in doing so. However, it will require integrating sustainability into infrastructure plans and aligning political institutions, such as public finance institutions. In addition, it is necessary to build close partnerships with private institutions to structure portfolios of sustainable investment projects. This can be used to support credit or issue green bonds.

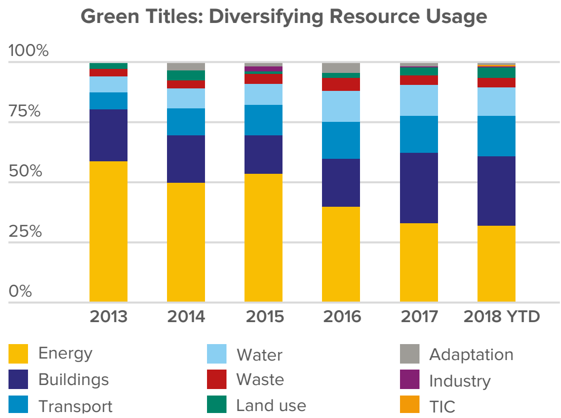
In addition to these channels, there are financing opportunities in the Brazilian capital market, for example, in expanding green bonds. Green bonds are fixed income securities[12] used to finance projects that have positive environmental attributes. These projects are typically characterized by assets and technologies that require long-term investments. They attract institutional investors such as pension funds, social security funds, insurers, and other asset managers.

Figure 6 shows the evolution of the global green bond market and the diversification of investments funded by these bonds in different sectors, highlighting energy, construction, and transport.

Figure 6

Green bonds - global evolution and use of resources by sector





Source: CBI, 2019.

Green bond issuance and loans have been expanding rapidly worldwide reaching a record US$202 billion in 2019 (CIB, 2019a; BHATTACHARYA *et al.*, 2019). The issuance of green bonds in Brazil has kept pace with positive international trends but has only reached a fraction of its potential. The Brazilian market is the main market in Latin America and the Caribbean, reaching about US$5.1 billion since 2014 (R$26.7 billion). Most maturing periods are between five and ten years (CBI, 2019). The current instruments of capital in Brazil are mainly focused on the agricultural and forestry sector: Agribusiness Receivables Certificate (CRA) and Agribusiness Letter of Credit (LCA). Combined, their markets reach more than US$46 billion.

12 Debentures, infrastructure debentures, Agribusiness Receivables Certificates, Certificates of Real Estate Receivables, and Investment Funds in Credit Rights.

These instruments lead to tax benefits for foreign investors. They can be traded as green bonds if their projects or assets are deforestation-free and sustainable (GREENBONDS, 2018). Improving regulatory aspects related to the capital market is a strategic option to stimulate infrastructure financing[13].

New accounting rules, such as the International Financial Reporting Standard (IFRS 16), lead to the creation of new contractual structures, such as Special Purpose Entities (SPE) or even structured investment funds such as the Credit Rights Investment Funds (FIDC) for technology financing. These changes may facilitate the transfer of operational risk and financing debt to agents who have a better understanding of associated risks.

13 In Brazil, the Brazilian Securities Commission (CVM) is responsible for overseeing the performance of agents in the capital market. The FIDC used in technology financing, for example, can be standardized – with greater legal and payment certainty – or non-standardized (FIDC-NP). In the latter case, the CVM restricts operations to professional investors (those that have financial resources above R$10 million) (CVM, 2014).

Box 8

The role of carbon pricing in the transition to a new economy

The transition to a green growth economy opens doors to Brazil's innovation in different sectors both by creating new markets and by an increased demand for new technologies. It can also generate opportunities for more innovative jobs. Carbon pricing is a mechanism that can help to drive efficiency and innovation, and generate revenue. Among financing opportunities, carbon pricing is considered one of the most cost-effective instruments to reduce GHG emissions. By pricing carbon, agents are led to compare their marginal cost of price mitigation, opting for the cheapest form of mitigation.

Internationally, there is an increase in the number of carbon pricing initiatives, resulting in increases in revenue to national governments. In 2018, the amount raised through carbon pricing initiatives was US$44 billion (R$230 billion). The carbon prices ranged from US$1-127 t/$CO_2$ (R$5-665 t/$CO_2$). So far, 77 countries, states, or municipalities around the world have adopted or are about to adopt one, representing 20.1% of total global GHG emissions (WORLD BANK, 2019a). In North and South America, Canada, Colombia, Argentina, Mexico, and Chile have already adopted carbon pricing in their economies. In the United States, ten states have implemented it and several other states are discussing it (WORLD BANK, 2019b).

Pricing carbon is an opportunity to help transition sectors into a world that is shifting to low-carbon economies. There is, for example, the structuring of investment and development plans such as the European Green Deal (EUROPEAN COMMISSION, 2020), which fosters emission neutrality in Europe without prejudice to the competitiveness of its national sectors. Such initiatives can affect the Brazilian trade balance, hindering or favoring the competitiveness of inputs and manufactured products intended for export. Therefore, implementing carbon pricing involves a difficult political decision.

In the national context, Brazil could benefit greatly from carbon pricing if supported by the Brazilian private sector. The Brazilian initiative the Partnership for Market Readiness (PMR) proposes different carbon pricing policy designs tailored to the national reality. It highlights potential economic impacts, theoretical motivation for the adoption of carbon pricing mechanisms, and the international state of play (PMR Brasil, 2017). Additionally, more than 400 companies, representing 90% of Brazil's market capitalization, signed an open letter in 2017 through the Brazilian Business Council for Sustainable Development (CEBDS) expressing support for the establishment of a carbon pricing mechanism in Brazil.

From the perspective of the productive sector, there is a growing opportunity for carbon pricing in terms of adequacy to international standards and competitiveness rather than revenue (CEBEDS, 2017). It is important to analyze how this system will affect Brazilian companies, not only in terms of cost, but especially in terms of competitiveness. A robust Measurement, Reporting and Verification (MRV) system is fundamental to enable and create a reliable database.

7

POLICY ENTRY POINTS FOR THE KEY RECOMMENDATIONS

This section presents the viability, attractiveness, and multiple benefits Brazil may enjoy by advancing towards a new economy to federal government decision-makers. Although extensive, the list of recommendations and policy entry points listed in the Appendix is not exhaustive. However, they can serve as a starting point to guide new discussions.

A Policy Entry Point (PEP) lens of analysis was used to demonstrate how this study's recommendations can be better incorporated within policy actions of Brazilian Federal Institutions. For the purpose of this document, a Policy Entry Point (PEP) is considered as any public policy (including governmental programmes, projects, and committees) that could serve as a channel of reception, discussion, and implementation of the recommendation being proposed.

The development stage, or readiness, of a channel to successfully receive and implement the recommendation matters in this analysis.

The readiness of each PEP highlighted is classified into two basic levels:

I. quick implementation

II. further development.

The "quick implementation" level can be understood as low-hanging fruit where advocacy efforts should be initially placed. The "further development" level is also a key component, but is one that requires additional development and consideration in the governmental policy pipeline.

To apply the PEP lens, we consulted ministerial websites, policy documents, and legislation. We then analysed how current federal policies, programmes, and projects could offer synergies in establishing the New Economy for Brazil in the infrastructure, agriculture and energy sectors. Analysis is also provided for synergies with the foreign trade and finance.

7.1 Infrastructure

Infrastructure is key to achieving a prosperous and dynamic economy. In the 21st century, infrastructure investments face a triple challenge, needing to simultaneously address economic, social, and environmental issues. To tackle these issues, countries must leverage investment in quality infrastructure. In Brazil, such investments must focus on the following concerns: i) improving logistics and urban mobility, ii) preserving natural capital, and iii) increasing financing to infrastructure projects.

The table on the next page is a list of recommendations presented in this study and their respective PEPs to leverage quality infrastructure in Brazil.

NEB Recommendation	Policy Entry Point Key Ministry	Comments	Readiness Level
Improving the multimodal freight network	Transport Infrastructure Concessions Portfolio Ministry of Infrastructure (MINFRA)	Recent agreement between the MINFRA and the Climate Bond Initiative (CBI) (CBI, 2019) as well as the launch of sustainable directives (MINFRA, 2020) indicates a certain degree of convergence with NEB. To advance this NEB recommendation, we envision two straightforward actions in an eventual infrastructure package: i) a quantitative approach for multimodality related to more railways and waterways in the national logistic grid, and ii) a qualitative approach related to improvements in energy efficiency, which is especially relevant to road modality considering the increase in roadway infrastructure planned for the next years.	Quick implementation
Mainstreaming sustainability principles within infrastructure projects	Investment Partnerships Program (PPI) Ministry of Economy (ME)	PPI seems an appropriate channel to mainstream sustainability and quality infrastructure principles into several federal infrastructure projects (PPI 2020). It also supports subnational concessions, presenting the possibility to connect with subnational governments to mainstream quality infrastructure nationally. This recommendation could be developed by establishing a roadmap to implement sustainability principles within infrastructure projects. Led by the PPI Secretariat such a roadmap could address issues such as institutional capacities and training, regulation, environmental licensing, project financing, and operating infrastructure in line with sustainability principles. It can also be an opportunity to work in cooperation with TCU.	Quick implementation
Implementation of an integrated national logistics planning	Investment Partnership Program (PPI) Ministry of Economy (ME) Ministry of Infrastructure (MINFRA)	In June 2018, the Federal Government launched the National Logistics Plan (PNL) 2025 through the Empresa de Planejamento e Logística (EPL) cabotage and pipeline. It is suggested to revisit this important instrument in order to update it regarding the participation of each modal and incorporate the consequences resulting from the Covid-19 pandemic.	Quick implementation
Improvement in the structuring of infrastructure projects for concessions and PPP	Investment Partnership Program (PPI) Ministry of Economy (ME) Ministry of Infrastructure (MINFRA) Ministry of Mines and Energy (MME)	The federal government, through the PPI, ministries and sectoral regulatory agencies, has been seeking to improve the structuring of infrastructure projects.	Quick implementation

NEB Recommendation	Policy Entry Point Key Ministry	Comments	Readiness Level
Improving energy efficiency in the national transport system	RenovaBio Ministry of Mining and Energy (MME)	The RenovaBio is a clear entry point to this NEB recommendation. Some adjustments could improve the programme, such as the inclusion of the civil aviation sector (and its related types of biofuels, such as Bio-Kerosene) in its design. Moreover, the recent international turmoil in the oil sector must be taken into account by policy makers to maintain the integrity of the program.	Quick implementation
	Project for Market Readiness (PMR) Ministry of Economy (ME)	The PMR can be a governmental platform to assess carbon pricing alternatives for the Transport Sector. An assessment of the energy sector is being carried out by the initiative.	Quick implementation
	Contribution for Intervention in the Economic Domain (CIDE) Ministry of Economy (ME)	By distinguishing fuels according to their emission factor, CIDE could be reframed to become a green tax. With the current economic situation unleashed by the COVID-19 pandemic and instability in oil markets, such an entry point has gained relevance. It could also be framed as an urgent measure to mitigate negative economic impacts on the Brazilian sugar-energy agribusiness.	Quick implementation
	Pró-Transporte Ministry of Regional Development (MDR) and Caixa Econômica Federal (CEF)	Pró-Transporte is a federal financing program for public transport systems (CAIXA, 2020). Resources for Pró-Transporte come from the FGTS, and the programme could include sustainability criteria to fund projects. This would open the possibility for the FGTS Committee to integrate sustainability principles into funding decisions.	Further development
Greening freight and interstate transport of passengers	Freight and Transport Services Concessions Ministry of Infrastructure (MINFRA) and related Regulatory Agencies	New low-emission infrastructure provisions, sectoral regulation, and planning operations toward better environmental performance could help Brazil achieve a new economy pathway.	Further development
Enhancing integration between urban planning and urban mobility	National Policy on Urban Mobility (PNMU) Ministry of Regional Development (MDR)	The full implementation of the PNMU (BRASIL, 2012) is key to a new economy. The following points require special attention: i) the preparation of Urban Mobility Plans up to the April 12, 2021 due date, and ii) implementation of policy instruments, such as traffic charges and low emission zones, already provided for by the PNMU.	Further development
Developing financial tools to leverage quality infrastructure	The Social Discount Rate Ministry of Economy (ME)	The successful establishment of a Social Discount Rate could be an important driver of quality infrastructure in Brazil. Therefore, it could serve as an entry point to NEB recommendations in this regard.	Quick implementation

NEB Recommendation	Policy Entry Point Key Ministry	Comments	Readiness Level
Considering climate change scenarios in infrastructure planning	Development of an appropriate set of regulations, guidelines, and contract templates to address issues Ministry of Economy (ME) (suggested locus)	Currently, there is no specific program addressing this matter in an integrated way. As key players in the development of national infrastructure projects, PPI and BNDES could coordinate governmental efforts to develop a Federal Programme on climate change risks to infrastructure planning. The National Adaptation Plan (PNA) could serve as a starting point for such an initiative. MINFRA, MME, MDR, and the Federal Court of Accounts (TCU) should also be involved.	Further development
Conserving water resources	National Policy on Water Resources (PNRH) and Forest Code Ministry of Regional Development (MDR) and Ministry of Agriculture (MAPA)	The PNRH (BRASIL, 1997) still has some implementation bottlenecks. As previously highlighted, improvement in forest cover could be one of the best ways for Brazil to enhance water conservation. There are many potential ways to better implement the PNRH by integrating it with Forest Code (BRASIL, 2012b) instruments, namely: i) CAR, PRA, and CRA, and ii) payment for environmental services. Forest restoration opportunities arising from the Nation Plan for Recovery of Native Vegetation (PLANAVEG), as well as forest concessions to recover federal degraded lands, could also be included in this integrative effort.	Quick implementation
Managing disaster risk reduction and socio-environmental risk assessment	Rio declaration on climate risk Ministry of Economy (ME)	The "*Rio declaration on climate risk transparency by the Brazilian insurance industry*" was signed by SUSEP-ME and the Brazilian Insurance Confederation (CNSeg) (UNEP, 2018). With this document, both organizations declared their support for the Financial Stability Board´s (FSB) Task Force on Climate-related Financial Disclosure recommendations. The Rio Declaration has great potential synergism with the NEB. One possible approach to unlock this recommendation could be the establishment of a working group within the Ministry of Economy led by SUSEP to develop a strategy converting this declaration into regulatory improvements.	Quick implementation
	National Policy on Protection and Civil Defence (PNPDEC) Ministry of Regional Development (MDR)	The PNPDEC (BRASIL, 2012c) has already been implemented. Communication channels between policy on climate change risks should be explored in the NEB.	Further development
	Core legislation for infrastructure projects Ministry of Economy (ME) (suggested locus)	The National Congress is discussing different legislative proposals of critical importance to improve the assessment of socio-environment risks and impacts, namely: i) Bill nº. 3729/2004 (Environmental Licensing), ii) Bill nº. 7063/2017 (Concessions and Public-Private Partnerships), iii) Bill nº. 1292/1995 (Public Tendering), and iv) Bill nº. 191/2020 (Mining and Energy Projects on Indigenous Lands). An integrated assessment of these proposals could enhance synergies, avoid policy gaps, and promote better governance of risks to infrastructure projects.	Further development

7.2 Industry

Brazil can solidly benefit from global trends in the industrial sector in the coming decades. To do so, the country must pursue an innovation strategy which fully unleashes its comparative advantages in this new industrial economy. For instance, building momentum in key sectors, such as i) renewable energy, ii) transport, iii) biofuel, and iv) housing and civil construction. The following recommendations are key pathways to unleash innovation and to help Brazil achieve a modern national industry.

NEB Recommendation	Policy Entry Point Key Ministry	Comments	Readiness Level
Fostering innovation in the renewable energy industrial sector	The Brazilian Agency for Industrial Development (ABDI) Projects Ministry of Economy (ME)	A transformative change in Brazilian industry towards a new economy is likely to happen through innovation policies rather than interventionist-oriented policies (*e.g.*, National Champions strategy). Therefore, an entry point could be ABDI projects. The ABDI is an executive agency linked to the ME that focuses on promoting investments in innovation and competitiveness in the Brazilian industry sector. Among ABDI projects, two are highly relevant to the NEB pathway: i) Inteligência (ABDI, 2020), and ii) Cidades Inteligentes (ABDI, 2020b).	Quick implementation
	National Policy on Innovation (PNI) Ministry of Science, Technology, Innovation and Communication (MCTIC)	The National Policy on Innovation is currently under development by the MCTIC (MCTIC, 2020). With a ten-year time horizon, it will be the main driver of the federal government regarding innovation. To mainstream innovation in the renewable energy sector, this recommendation must be fully considered in the PNI. Possible issues in this regard include i) financing innovation, ii) building institutional capacity, and iii) enabling a research network for the renewable energy industry.	Further development

NEB Recommendation	Policy Entry Point Key Ministry	Comments	Readiness Level
Improving the use of residuals for energy	National Policy on Solid Waste Management (PNRS) Ministry of Environment (MMA)	The use of solid waste for energy is already provided for in the PNRS (BRASIL, 2010) as one of the mandatory components of the National Plan on Solid Waste. This recommendation could be enhanced if the Federal Government overcomes current regulatory and institutional bottlenecks in this field.	Further development
Unlocking the industrial potential of transport electrification	Rota 2030 Ministry of Economy (ME) PROMOB-e Ministry of Economy (ME) and Ministry of Regional Development (MDR)	Arguments for the electrification of transport are gaining momentum in Brazil, especially regarding urban mobility. There are relevant entry points in two governmental initiatives, namely Rota 2030 (MINISTRY OF ECONOMY, 2020) and PROMOBE-e (MINISTRY OF ECONOMY, 2020a). Rota2030 already offers some incentives for the adoption of electric and hybrid vehicles. However, during the assessment of the upcoming first cycle (2022), some aspects should be considered, namely i) the inclusion of key sectors that are not traditionally related to the automobile industry, such as electric battery and fuel cell producers, ii) the inclusion of trending issues of electromobility such as a) autonomous and self-driving cars, b) big-data and technological platforms, and c) regulatory and infrastructure barriers for electric vehicles charging stations:, iii) increasing tax incentives to the electromobility industry.	Quick implementation
	Improving regulation and economic modelling Ministry of Economy (ME) (proposed locus)	Transport electrification faces critical economic bottlenecks. We believe that NEB recommendations could gain momentum if the Federal Government was able to overcome the following issues: i) development of new business models in urban transport systems that consider structural difficulties that many medium and small Brazilian cities face in incorporating electric buses in their public transport systems, and ii) the need for developing a proper business environment for electric buses in Brazil. A starting point could be proposed legislation to phase out fossil fuel vehicles in Brazil, currently under consideration in the National Congress (BRASIL, 2017).	Further development
Improving biofuel consumption in the Civil Aviation Sector	RENOVABIO Ministry of Mining and Energy (MME)	The Brazilian biofuel potential highlighted in this study (HVO, biokerosene, and bio jet) have a promising entry point in the RENOVABIO program. Fuel is one of the main components in the typical operational cost structure of a civil aviation company. Incorporating the civil aviation sector into the RENOVABIO program could have positive impacts on this sector, especially regarding the sector´s recovery in the post-pandemic scenario.	Quick implementation
Enabling the development of ethanol fuel cells	National Council on Energy Policy (CNPE) Ministry of Mining and Energy (MME)	As one of the world's largest ethanol producers, Brazil could benefit from the development and large-scale use of ethanol fuel cells. There is a promising partnership between Nissan and the Institute of Nuclear and Energy Research (IPEN) on this issue. However, Brazil does not have a structured policy/program around it.	Further development

NEB Recommendation	Policy Entry Point Key Ministry	Comments	Readiness Level
Improving energy efficiency in the civil construction and housing sectors	Partnership for Market Readiness (PMR) Ministry of Economy (ME)	An energy-efficient civil construction industry could be fostered through two channels: economic disincentives and additional financing. For instance, the use of carbon pricing associated with credit lines could drive the civil construction sector towards a greener path. This recommendation could be initially evaluated under the current governmental initiatives such as the PMR (Ministry of Economy), the PROESCO (BNDES), and PROCEL (ANEEL).	Further development
Unlocking the low-carbon cement industry	Low-Carbon Industry Technical Chamber (CTIB) Ministry of Economy (ME)	The cement production chain offers multiple opportunities to improve sustainability, as pointed out in this study and in a recent technological roadmap prepared by the National Union of the Cement Industry in 2019 (VISEDO and PECCHIO, 2019). Considering the absence of a specific policy to address this issue, this recommendation should be assessed by the Low-Carbon Industry Technical Chamber (CTIBC) of the Ministry of Economy.	Further development

7.3 Agriculture

As a global player in the agriculture sector, Brazil has opportunities to improve its leadership position. To do so, Brazil must adopt a policy approach that combines productivity gains with natural capital preservation. Based on a fourfold model, which comprises i) the use of low-carbon techniques, ii) logistics for production, iii) land use management, and iv) knowledge development, this study has the following recommendations for Brazilian agriculture.

NEB Recommendation	Policy Entry Point Key Ministry	Comments	Readiness Level
Intensifying the use of sustainable-technological solutions in agriculture and cattle raising	ABC Programme and Safra Plan Ministry of Agriculture (MAPA)	Provisions for low-carbon agriculture technologies are already addressed by the ABC Plan (e.g., Pastureland Recovery; Direct Seeding (SPD), Biological Nitrogen Fixation (BNF), Agroforestry Systems (AFSs), Integrated Cropland-Livestock-Forestry Systems (iLPFs). Currently the ABC Programme is couched as a technological package instead of a transformative instrument that would enable a new agriculture model based on sustainable-technological approaches. We propose two simultaneous actions to make the ABC a feasible tool for wider change: a) Program conditions: currently, the ABC program lacks the scale and resources to mainstream sustainable-technological solutions encompassing all Brazilian agriculture. For instance, the ABC program credit supply represents around 1% of the Safra Plan credit supply, which reached R$ 200 billion in 2017/2018. Moreover, the average interest rate (7% p.a.) does not offer a significant discount compared to other market options. Therefore, an eventual reform of the ABC must address such issues by reducing interest rates, increasing the amount of credit for this program, and easing payment conditions (loan terms and grace period). b) Program scope: improvements in program design could help meet the recommendation, namely i) improve program monitoring to better highlight program outcomes, ii) design a better communications plan regarding the positive impacts of Low-Carbon Agriculture (including an eco-labelling initiative), iii) incorporate (or tighten connections to) the MODERAGRO and INOVAGRO programmes, iv) create a specific credit line related to adaptation to prevent losses and build resilience, and v) improve technical capacity related to the low-carbon agriculture business, including in financial institutions. The Safra Plan (MAPA, 2019) could play a critical role in unlocking this recommendation. In fact, the best scenario is the Safra Plan becoming a low-carbon agriculture plan in the long-term. To do so, a transitional strategy could be developed by considering the following features: i) including low-carbon techniques as part of criteria for conceding rural credit, ii) increasing the amount of investments and providing better financial conditions (e.g., reducing interest rates, extending grace periods, and the contracts length) for investments with spill-over effects on low-carbon techniques and adaptation, iii) providing better rural insurance conditions for activities based on low-carbon techniques, iv) strengthening risk management instruments and rural extension activities, and v) linking rural credit with Forect Code compliance. Finally, this NEB recommendation could also help bring about low-carbon pathways in the agriculture sector by connecting with the National Program for Family Agriculture Strengthening (PRONAF). PRONAF has great potential regarding income generation and job creation in a new economic environment. Better integration between PRONAF, Safra Plan, and ABC Programme would be welcome in this context.	Quick implementation

NEB Recommendation	Policy Entry Point Key Ministry	Comments	Readiness Level
Intensifying the use of sustainable-technological solutions in agriculture and cattle raising	National Policy on Irrigation (PNI) Ministry of Regional Development (MDR)	Brazil only has 6-7 million ha of irrigated area, despite having the potential for 60 million ha. Low-carbon irrigation techniques can help the country reduce this gap. As Brazil already has a National Policy on Irrigation (BRASIL, 2013), the best way to foster this recommendation is by developing a common agenda that incorporates low-carbon techniques into PNI implementation. This approach could be quickly effective, since the National Congress is considering proposed legislation updating the PNI.	Further development
Improving logistics for agricultural products	Transport Infrastructure Concessions Ministry of Infrastructure (MINFRA)	Recent efforts to promote railway infrastructures in Brazil, especially in the North, are fundamental to Brazilian agriculture. Besides the Ferro-Grão Railway (already included in the PPI Portfolio), the completion of the North-South railway in the state of Para (Barcarena/PA - Acailândia/MA) (VALEC, 2020) is also relevant to improving sustainability in the agriculture sector.	Quick implementation
Leveraging Pastureland Recovery	Safra Plan Ministry of Agriculture (MAPA)	Considering the tendency for growth in terms of agriculture lands in this decade, this recommendation is key to maintain Brazil's global leadership position and avoid deforestation. However, the lack of financing and technical assistance are major issues in unlocking pastureland recovery. The reconfiguration of the SAFRA Plan, as suggested earlier, and the strengthening of the ABC Programme are effective ways to address such issues.	Quick implementation
Leveraging Pastureland Recovery with Forestry Restoration	National Policy on Recovery of Native Vegetation (PROVEG) Ministry of Environment (MMA)	The Planaveg (within the PROVEG) is a key governmental plan to improve pastureland recovery through forestry restoration in Brazil. However, this plan has issues in terms of financing and economic modelling. The NEB initiative could collaborate with the Federal Government on these aspects (financing and modelling) to fully implement this recommendation.	Quick implementation
	Forest Concessions in degraded federal areas Ministry of Agriculture (MAPA)	Law nº. 11,284/2006 allows the Federal Government to promote forest concessions to recover degraded Federal lands. So far it has not been implemented. Two important highlights are i) Sustainable Forest Management (SFM) concessions managed by the Brazilian Forest Service (institutionally subordinated to MAPA), and ii) in 2019, the PPI included some SFM concession units in PPI's list of priorities.	Further development
	Food Acquisition Program – Seeds (PAA-Sementes) Ministry of Citizenship (MC)	Agricultural inputs are needed to leverage pastureland recovery with forestry restoration practices. Seed production, especially of native trees, is likely to be one of the most difficult bottlenecks to overcome. The initiative could support the Ministry of Citizenship and the National Company of Supplying (CONAB) in redesigning the processes of the PAA-Sementes (BRASIL, 2020) to make this programme a key instrument to overcome this barrier.	Further development

NEB Recommendation	Policy Entry Point Key Ministry	Comments	Readiness Level
Building technical knowledge	Plataform ABC Ministry of Agriculture (MAPA) Zarc Plantio Certo App Ministry of Agriculture (MAPA)	Two Embrapa (MAPA) initiatives could serve as entry points to develop strategies for the agricultural sector: the Plataforma ABC (EMBRAPA, 2018) and the recently launched Zarc Plantio Certo App (EMBRAPA, 2019), which aims to help farmers choose the best time to plant their crops based on climate risk zoning conditions (ZARC).	Quick implementation
Improving technical assistance	National Policy for Technical Assistance and Rural Extension (PNATER) Ministry of Agriculture (MAPA)	The PNATER (BRASIL, 2019), which focuses on strengthening family farming, could be an entry point to improve technical assistance and rural extension towards a sustainable agriculture in the new economic perspective.	Further development

7.4 Trade and Financing

Sustainability concerns are a growing trend in trade and capital markets worldwide. As a global leader in agriculture and food production, and having a strong dependency on international and national capital to overcome lack of investment in infrastructure. The following table presents a few possibilities.

NEB Recommendation	Policy Entry Point Key Ministry	Comments	Readiness Level
Showcasing the relevance of natural assets in Brazilian GDP	Green Internal Product Law Ministry of Economy (ME)	Law nº. 13,493/2017 establishes that the IBGE must consider ecological assets in the System of Natural Accounting through a periodical counting of the Internal Green Product (PIV). Such methodology should follow UN principles and must be comparable with other countries' values (IBGE, 2019). PIV accounting could serve as an appropriate entry point to unveil the economic relevance of natural capital.	Quick implementation
Enhancing Environmental Conservation	Legal Amazon National Council Brazilian Vice Presidency	The importance of enhancing natural capital conservation was strongly highlighted in this study. As a major source of risk to Brazil´s reputation, deforestation of the Amazon is at the centre of such concern. Therefore, the recently-reframed Amazon Council coordinated by the Brazilian Vice-Presidency is a relevant entry point to channel this recommendation in the Federal Government (BRASIL, 2020b).	Further development
Leveraging Low-Carbon Agricultural Techniques	Safra Plan Ministry of Agriculture (MAPA)	Low-carbon techniques are of critical importance to improve productivity and avoid reputational risks in the international market. As previously highlighted in recommendations for the agricultural sector, the Safra Plan could be used to mainstream these techniques throughout the Brazilian agricultural sector. In so doing, the Safra Plan could also help to unlock additional financing possibilities for Brazilian agricultural production, such as the Green Climate Fund (GCF).	Quick implementation
Negotiating better trade conditions for nature-based solutions	Chamber of Foreign Trade Ministry of Economy (ME)	There in an unexplored potential in international trade negotiations that the NEB initiative could help to unleash. One example is the use of natural assets to produce important items in the international agricultural trade chain, such as soybeans and cellulose. Moreover, there are opportunities in the tropical timber market; wood production could benefit from current federal forest concessions. Sustainable techniques and the (necessary) intensive use of natural resources must be clearly priced in trade agreements in which Brazil takes part.	Further development

NEB Recommendation	Policy Entry Point Key Ministry	Comments	Readiness Level
Including sustainability criteria in developing projects	Capital Market Initiative (IMK) and Agenda BC+ Brazilian Central Bank (BCB)	The inclusion of sustainability criteria in infrastructure projects reliant on foreign investments should be on the "to-do list" of any PPI, MINFRA, and MME project. Therefore, a possible entry point could be a discussion about this topic in the PPI Council, with all interested Federal Ministries participating (PPI, 2020). As one of the key players in the Federal infrastructure project sphere, we also recommend channelling this recommendation to the TCU.	Quick implementation
Accessing Green and Climate Bonds Market	Green Bonds Talks Ministry of Infrastructure (proposed locus) (MINFRA)	MINFRA is starting to consider low-carbon issues in its portfolio of infrastructure concessions to attract foreign investments. The recent cooperation agreement between the Ministry and the Climate Bond Initiative (CBI, 2019) as well as Ministerial sustainable (MINFRA, 2020) directives confirmed this view. MINFRA could therefore serve as an entry point for such a recommendation. Moreover, we also recommend including BNDES in such an initiative to develop a whole-of-government strategy in this regard.	Quick implementation
Mainstreaming green financing mechanisms and tools	Capital Market Initiative (IMK) and Agenda BC+ Brazilian Central Bank (BCB)	In June 2019, the Brazilian Central Bank (Ministry of Economy) launched the IMK, a Federal Government strategic action part of the Agenda BC+ (BCB, 2019) to develop the national capital market. The Ministry of Economy, Brazilian Securities Commission (CVM), and Superintendency of Private Insurances (SUSEP) are also parts of the initiative. Due to this, the IMK can be a clear entry point to internalize this recommendation in the Federal Government.	Quick implementation
	Financial Innovation Laboratory (LAB) Ministry of Economy (ME)	The Ministry of Economy already has an important initiative in which this recommendation could be further explored: the Financial Inovation Lab. The Secretary of Economic Policy (SPE) and other relevant institutions, such as IDB and CVM, are discussing economic instruments to green the internal financial market (LAB, 2020).	Quick implementation

FINAL REMARKS

A Bold Transition Towards a New Economy for Brazil

Brazil faces several challenges, including the dire health and economic crisis facing the world. Brazil needs to be pragmatic and creative to boost growth in the short-term and capture private investment for its development. More than in any other crisis faced in the past, public and private initiatives that will follow this health emergency are crucial in defining Brazil's socioeconomic future and sustainability.

This study presented strategic opportunities that Brazil and its leaders have at hand in a century where the use of natural resources needs to be rethought for economies to remain competitive, especially in infrastructure, industry, and agriculture. It analyzed policy options and measures capable of stimulating, in the short- and medium-term, growth in key sectors of Brazil with a more efficient allocation of production factors and benefits of capital and natural resources. The study highlights the need for improvements in some government actions, in order to strengthen the path towards a new economy for Brazil. Such recommendations can allow for “win-win” situations, unlocking income generation, employment and innovation.

This study also integrates the economic goals of the Brazilian government with a low-carbon growth agenda and identifies the possible benefits of economic, social, and other developments. This includes impacts on the growth of gross domestic product (GDP), job creation, income distribution, health benefits, and fiscal sustainability.

This study provides indications of the potential for strategic public investments to attract the private capital needed to implement the opportunities identified. Some, such as the bioeconomy, are more impactful and ready to be capitalized on. While the focus of this study is on opportunities for the federal government, there are also several opportunities for subnational governments and the financial and private sectors. Further analysis must be conducted to assess and exploit such synergies, especially in the Amazon region.

The modeling analysis used in this study (and further detailed in Appendix A) indicates that pursuing a sustainable pathway can lead to higher GDP growth than that of business-as-usual. The total cumulative gain in GDP is US$535 billion (R$ 2.8 trillion) between 2020 and 2030, compared to business-as-usual. This could also lead to a net increase of more than 2 million jobs in the Brazilian economy by 2030. Finally, it could also reduce greenhouse gas (GHG) emissions, beyond Brazil’s commitments to the Paris Agreement on climate change, with a reduction of 42% in 2025 compared to 2005 levels. Climate change scenarios are considered a strategic risk factor by the world's largest investors. Therefore, this study also emphasized the importance of considering these scenarios and their implications in terms of food, water, and energy security for long-term planning.

Positive growth impacts can begin immediately by implementing and strengthening the technologies and measures discussed in this study. This includes increasing the potential of rural credit programs to reward farmers for implementing advanced low-carbon practices and encouraging activities such as recovering degraded pastures and increasing productivity. Another option is to seek emerging commercial markets for biofuels, such as international aviation, and the development of ethanol fuel cells for long-haul trucks. This could empower Brazil, putting it ahead of market trends and best positioned to leverage its competitive advantages.

In the medium and long term, the success of these measures will depend on the construction of quality, sustainable infrastructure, including natural infrastructure, accompanied by an ambitious expansion and diversification of green financing. Investments in quality infrastructure have the advantage of creating jobs and growth immediately, but also of strengthening productivity and competitiveness down the line, in addition to preparing the country for the increasing damage caused by extreme weather events.

Public banks, such as the BNDES, must play a leading role. The expansion of private participation in infrastructure investment is also central. The mobilization of private funding and investment requires a favorable and stable business environment, which increasingly requires promoting sustainability as part of national infrastructure planning.

The alignment of instruments and political institutions to act as focal points in different parts of the planning and implementation process is critical. This alignment strengthens the functions of sectoral planning and identification, and the analysis of project feasibility. It also ensures that public finance institutions work closely with private companies to improve the quality of projects, aggregate them as portfolios, and create instruments to help exploit national and international resources for quality infrastructure. This set of policies can create a virtuous cycle that allows infrastructure gaps to be substantially reduced in a relatively short period.

It is essential that green growth be seen as a great opportunity to boost economic development in Brazil in a fast and sustainable way without compromising Brazil's unique and highly strategic natural capital.

This is the most promising economic growth model for Brazil in the short and long term. It represents historical opportunities for some of its most strategic sectors, such as agriculture, and for regions rich in natural and social capital. Brazil has remarkable opportunities to emerge from the social and economic crisis brought on by COVID-19, safer, more prosperous, inclusive, and more resilient.

Appendix A: Quantifying the Benefits of a New Economy for Brazil

A.1 Modeling Procedure

The modeling procedure methodology used to quantify the socioeconomic benefits of a New Economy for Brazil builds on and complements existing Brazilian studies on specific sectors. A set of scenarios was created through an interactive modeling framework that integrates two models: the Brazilian Land Use and Energy Systems (BLUES) and the Green Economy Model (GEM), which are described in this Appendix.

A.1.1 Brazilian Land-Use and Energy Systems model (BLUES)

BLUES is an optimization model for Brazil. It was built based on the MESSAGE model generation platform (Model for Energy Supply Strategy Alternatives and their General Environmental Impacts). The platform was designed to develop and evaluate energy supply alternatives considering constraints such as investment restrictions, fuel prices and availability, environmental regulations, market penetration rates for new technologies, and others.

BLUES is an extension of the MESSAGE-Brazil model, which was substantially updated and specified to evaluate issues related to the national reality and its scope expanded to include the land use sector. The energy system is represented in detail for transformation, transportation, and energy consumption sectors. There are more than 1,500 technologies customized for each of the six model's native regions.

Representation of land use systems includes forests, savannas, low- and high-capacity pastures, integrated crop-livestock-forestry systems, arable land, "off-season crops"[14], planted forests, and protected areas. The model minimizes the costs of the entire energy system, including electricity generation, agriculture, industry, transportation, and construction sectors. BLUES is subject to restrictions (in all variables) that represent real-world situations.

The NEB scenario aims to assess the penetration of low-carbon technologies that can affect energy consumption and reduce carbon emissions in the long term. For this study, the technologies presented in the table below were selected:

Table A1
Low-carbon technologies evaluated in this document

Sectors	Technologies
Transport	Hybrid vehicles
	Electric Vehicles
	Fuel cell vehicles (light, medium and heavy trucks)
	Aviation biokerosene
Buildings	Energy efficiency in buildings
Electrical sector	CSP and photovoltaics in hydroelectric reservoirs
Industrial	Increased use of charcoal in the iron and stee sector
Land use	High-productivity systems of agriculture and pasture

14 The period between soil preparation for planting until the next harvest

Currently, such technologies are not being extensively used in Brazil. However, they may represent technological options for the medium and long term. The methodology to evaluate the effects of penetration of these technologies is common to all sectors. Thus, for each technology, a penetration curve was plotted aiming to reach certain values by 2035. After this period, the penetration remained constant.

For the transport sector, the analysis considered the percentage of new vehicle sales. We stipulated that of the total sale of new passenger vehicles, 50% would be hybrid by 2035. Likewise, 50% of new buses will be electric by 2035. For trucks, the percentages varied between 20% for light and heavy trucks and 10% for medium trucks by 2035. In addition, in the transport sector the penetration of aviation biokerosene would reach 50% in relation to the consumption of total biokerosene by 2035.

In the residential sector, the gains in energy efficiency in appliances are reflected in the model through a reduction in demand. Thus, from 2025 there is a reduction of 3%, reaching a reduction of 10% in total demand by 2035. In the industrial sector, the use of charcoal in pig iron and steel segments was considered to the replacement of fossil fuels. For this, charcoal would have a penetration of 50% by 2035 in relation to the new capacities installed in this industrial segment.

For the electricity sector, we considered a solar energy penetration of 3% by 2025 and 6% from 2030 in relation to the total electricity generated. Of this generation, half was attributed to CSP technology and half to photovoltaic panels installed in hydroelectric reservoirs, according to Table A2 below.

Table A2

Electricity generation by CSP and Photovoltaic (PV) reservoirs

	Generation (%)		Generation (TWh)	
Year	CSP	PV_Reservoir	CSP	PV_Reservoir
2010	0.0%	0.0%	0.0	0.0
2015	0.0%	0.0%	0.0	0.0
2020	0.0%	0.0%	0.0	0.0
2025	1.5%	1.5%	10.6	10.6
2030	3.0%	3.0%	22.0	22.0
2035	3.0%	3.0%	22.2	22.2
2040	3.0%	3.0%	24.0	24.0
2045	3.0%	3.0%	25.8	25.8
2050	3.0%	3.0%	27.3	27.3

Finally, in the land use sector, two modifications were considered. First, a penetration of 30% of high-productivity areas for agricultural crops replacing the most inefficient areas.

Secondly, seeking to improve livestock productivity, low-productivity pasture technologies were penalized with an extra cost. These measures are listed in the table below:

Table A3

Penetration of technologies in the New Economy for Brazil scenario

	2020	2025	2030	2035	2040	2045	2050
Transportation (share of new sales)							
Hybrid flex-fuel vehicles	0%	17%	33%	50%	50%	50%	50%
Electric buses	0%	17%	33%	50%	50%	50%	50%
Fuel cell:							
Light trucks	0%	7%	13%	20%	20%	20%	20%
Medium trucks	0%	3%	7%	10%	10%	10%	10%
Heavy trucks	0%	7%	13%	20%	20%	20%	20%
Biojet (share of total kerosene)	0%	5%	20%	50%	50%	50%	50%
Buildings (demand reduction)							
Energy efficiency	0%	3%	7%	10%	10%	10%	10%
Power sector (share of total electricity)							
CSP + PV reservoir	0%	2%	4%	6%	6%	6%	6%
New materials (share of expansion)							
Charcoal (iron and steel)	0%	17%	33%	50%	50%	50%	50%
Agriculture							
High productivity (share)	0%	10%	20%	30%	30%	30%	30%
Pasture	**Extra cost for low-productivity technologies**						

The costs and performance characteristics (efficiency, capacity factors, environmental indicators, etc.) of technological alternatives are among the most important input data for the model. These values can change over the model time scale. Each primary power source can be divided into an optional number of classes considering extraction costs, quality of sources, and the location of warehouses. Such primary energy sources are transformed directly or indirectly into secondary and final energy sources, and finally into energy services to meet a previously defined exogenous demand. Energy demands are divided regionally and, in certain cases, based on the power demand after the system's load curve is plotted. The total cost of the system includes costs for investment and operation, as well as additional costs such as "penalties" for certain alternatives or environmental and social costs.

In recent years, the Brazilian version of MESSAGE has been substantially updated and applied to evaluate issues relevant to the national reality (KOBERLE *et al.*, 2015; ROCHEDO *et al.*, 2018; SZKLO *et al.*, 2018). Recently, the model has been completely redesigned to ensure a better detailing of both regional distribution and endogenous energy efficiency and greenhouse gas mitigation options in end-use sectors. It was also expanded to include land use, according to the methodology Koberle (2018) proposed. The model minimizes the costs of the entire energy system, including electricity generation, agriculture, industry, transport, and construction sectors, which are subject to restrictions (in all related variables) that represent real-world constraints.

BLUES has six regions. One represents nationwide processes in which five sub-regions are included based on Brazil’s geopolitical divisions. BLUES optimizes the power system between 2010 and 2050 in five-year intervals. It minimizes the total cost of the system and has a perfect foresight in relation to future technical-economic and policy conditions. Each representative year is divided into 12 representative days (one for each month) composed of 24 representative hours.

In other words, there are 12 load curves of 24 hours each, leading to a total of 288 divisions of time per year. Power generation must balance supply for each division of time. Intermittent sources are restricted to 25% of total power generation capacity (MIRANDA *et al.*, 2017). In addition, a fully dispatchable technology must be implemented together with a capacity reserve. The demand sectors are divided into industry, transport, buildings (residential, commercial, and services), and agriculture, each detailing the level of energy services (e.g., process heat, mobility, lighting, etc.).

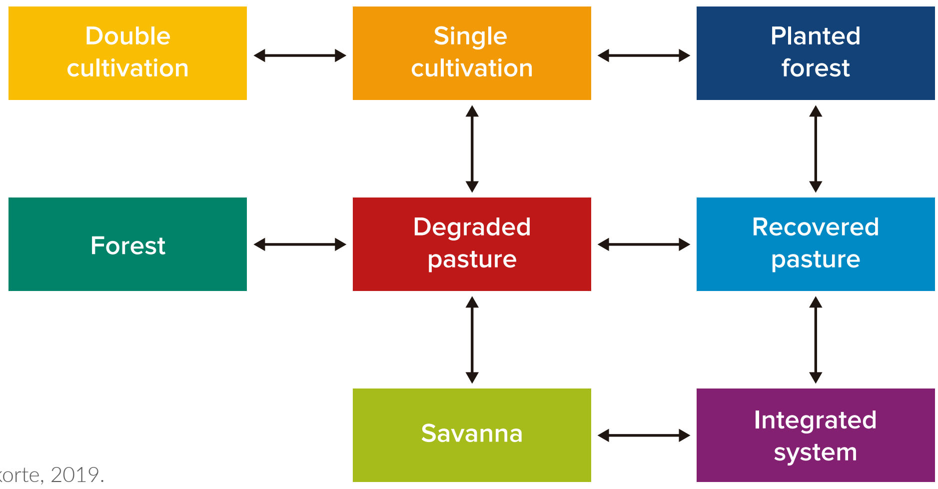
The growing area includes the main agricultural products in Brazil. It follows the definitions of the United Nations Food and Agriculture Organization (FAO, 2017): Wheat, Fruits, Soybeans, Corn, Cereals, Beans, Roots, Rice, Legumes, Oilseeds, Nuts, Cane, and Coffee, as well as Woody and Grass biomass.

Woody biomass can come from planted forests and/or forest residues. Agricultural waste can also enter the biomass chain. The "off-season crops" of soybean-corn and soybean-wheat are represented in the model. There are three productivity categories for each main temporary crop (soybean, corn, wheat, and rice).

The model delivers enough agricultural production to meet exogenous demands at a minimal cost. It expands the agricultural area, if necessary, and thus models the transitions in land use over time. Figure A1 shows land use transitions modeled in BLUES. It is important to note that any unitary area of land can go through more than one transition in a single interval, so that all classes of land use are interconnected. Costs are modeled individually for each transition and accumulate as an area unit undergoes consecutive land use transitions.

Figure A1

Land use transitions modeled on BLUES



Source: Angelkorte, 2019.

A.1. 2 The Green Economy Model for Brazil

The Green Economy Model (GEM) is a system dynamics model that integrates socio-economic indicators with the natural capital that support them (PROBST and BASSI, 2014). It is designed to help policymakers identify environmentally sustainable paths consistent with the attainment of medium- and long-term development targets, thereby enabling the transition to a more inclusive, robust, and green economy. GEM allows for a better understanding of social, economic, and environmental co-benefits associated with sustainability policies. It incorporates core biophysical representations for natural capital, an economic structure that abides by core economic principles, covers definitions and identities as defined in the System of Environmental and Economic Accounts (SEEA), and offers other mechanisms to represent policy mechanisms and potential elements of resistance to policies. GEM provides policy and investment outcomes across sectors, economic actors, dimensions of development, over time, and in space (if modeled together with spatial models).

GEM's integrated approach recognizes the environment as a base for ecological resources that provides materials and services to economy and society. The economic sector transforms these inputs into desired goods. The economic and social processes of creating and using these goods produce waste, pollution, and other stressors that can return to the environment and potentially imperil its ability to provide future inputs. By applying this framework, GEM is designed to allow stakeholders and policymakers to think creatively about how to best address environmental problems and maximize sustainability in an analysed country or region. In particular, the model aims to facilitate discussion of a broad range of potential green economy interventions – e.g., energy efficiency, renewable energy, reforestation, water efficiency improvement, waste reuse, sustainable agriculture development – by illustrating the effects of each intervention on important economic, environmental, and social indicators.

Depending on the scope of work, data availability, and associated policy issues, GEM can be designed at a country level as well as for selected sectors and regions. As a model that aims to represent a system's structure by reproducing its behavior, GEM incorporates country or region-specific characteristics relevant for both policy and development, including insights on any potential unintended consequences of interventions. Participatory modelling ensures stakeholders understand the structure and function of the model, thus increasing the likelihood of buy-in and adoption of the model as a tool for policy analysis, capacity building, and an adequate representation of the problem at hand.

The GEM-Brazil model was designed to include all major sectors relevant to the future development of Brazil. Among them are: population, food supply and demand, land use, sector and aggregate economic activity, employment, access to health services, education, supply and energy demand (linked to the BLUES model), atmospheric emissions, water pollution, and climate trends. The model also provides an economic assessment of the following externalities: atmospheric emissions (social cost of carbon), air pollution, wastewater, solid waste discharge, traffic-related impacts (e.g., accidents and noise), water opportunity cost (economy in the agricultural sector), and biodiversity.

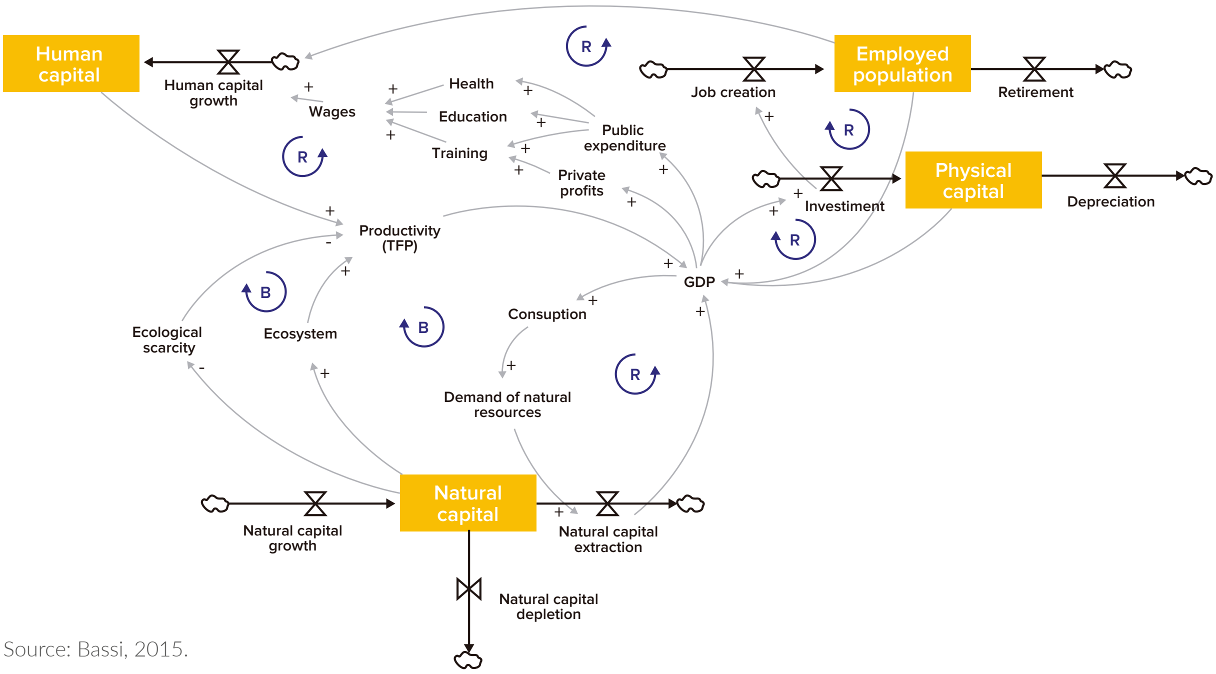
GEM-Brazil includes four key types of capital (built or physical, human, social, and natural) interconnected by the explicit representation of feedback loops (reinforcing or balancing). Policies can be implemented to strengthen growth (i.e., reinforcing loops) or curb changes (e.g., by strengthening balancing loops). In this specific study, GEM was used to (1) test the effectiveness of individual policies and investments by assessing their impacts inside and across sectors, and application to social, economic, and environmental indicators, and (2) inform development planning by assessing the outcomes of a simultaneous implementation of various intervention options.

Figure A2 below shows a high-level overview of selected key relationships included in GEM.

The figure is not a full representation of the model but is included here for illustrative purposes. Depending on the level of complexity implied by the system represented and the associated policies, GEM can include hundreds to thousands of climate, environmental, and socio-economic variables, many of which are endogenously determined.

Figure A2

Key features of the Green Economy Model (GEM)



Source: Bassi, 2015.

The figure above highlights the key features of GEM, including:

- **Feedback relations:** Feedback is a process whereby an initial cause ripples through a chain of effects ultimately to affect itself. The arrows in the model indicate causation and relations of dependence. Variables move in the same direction (a positive sign in the arrowhead) or in the opposite direction (a negative sign in the arrowhead). Many causal loops (feedbacks involving two or more variables) are included.

  For instance, a higher economic output (GDP) increases expenditure demand, including the use and possible depletion of natural resources, leading to higher GHG emissions and a reduction in the availability of environmental goods and services. This, in turn, negatively affects human capital and the productivity factor, thus affecting future economic outputs.

- **Stock-flow relations:** These characterize variables and behaviors of social, economic, climate, and natural capital systems. For instance, capital stocks are built from net investments. GHG concentrations result from GHG emissions. Natural capital accumulate from a biophysical build-up of forests, lands, fisheries, etc., and decreases with productive extraction and degradation. Stock-flow relations, a key feature of GEM, replicates the behavior of the system and represents its structure.

- **Asymmetric effects:** changes in a specific input or variable produce uneven marginal effects on the associated variables, depending on the level and intensity of the initial input variable. For instance, increases in air pollution concentration in the atmosphere exacerbate health damages. This could be indicated by particulate matter (such as PM2.5) in parts per million. Delays refer to the time for a particular policy to be implemented and for the resulting impact to appear, thereby increasing the variability of its impact on selected targets, which in turn influences system outcomes. All these features are incorporated in GEM.

- **A structural approach to modelling:** Some of the elements included in the figure above are representative of fully developed structures for economy, climate, and natural capital systems. GEM features socio-economic representations for the real sector, including value addition and employment across sectors, expenditure categories, real prices, fiscal balances, public debt, the external sector, demographics, and labor supply. GHG emissions of key sectors (land, energy, domestic and industrial waste, industrial processes, and product use) are computed as well. GEM also provides full representations of the energy sector (e.g., supply from primary sources and how they transform to satisfy demand by energy type in both renewable and non-renewable sectors), forests and land use (e.g., agricultural sector classified by key crops), water resources (e.g., oceans, fisheries), and ecosystem services (constructed based on their biophysical characteristics).

- **Calibration and use for developing policy insight:** To ascertain the extent to which GEM structures adequately represent the systems, the model is calibrated for a given historical period (typically 2000-2018). The calibrated model is used to develop baseline and alternative policy scenarios based on policies and inputs agreed upon in the participatory modelling process. GEM is solved recursively, generating endogenous outcomes for a period that can extend to 2050 and beyond.

GEM is built using system dynamics modelling, based on systems thinking in a modular fashion. It connects interdependent structures of economic, energy, land, and social systems following consultation with clients and stakeholders. The use of system dynamics allows for incorporation of the typical non-linearity nature and delays in stock-flow and feedback relations that characterize complex systems.

The following are structures or modules normally built in a GEM:

- Demographics and labour supply

- Macroeconomy, including the Real, Fiscal, and External sectors

- Sector-level sub-structures that represent economic activity (e.g., agriculture by crop type, types of industry and services) and shed light on selected issues (e.g., gender, welfare, carbon markets, etc.)

- Natural capital based on biophysical structures, including GHG emissions, energy, land and agriculture, water, oceans, fisheries, and biodiversity

- Policy structures tailored to country/ regional characteristics and problems or specific policy questions

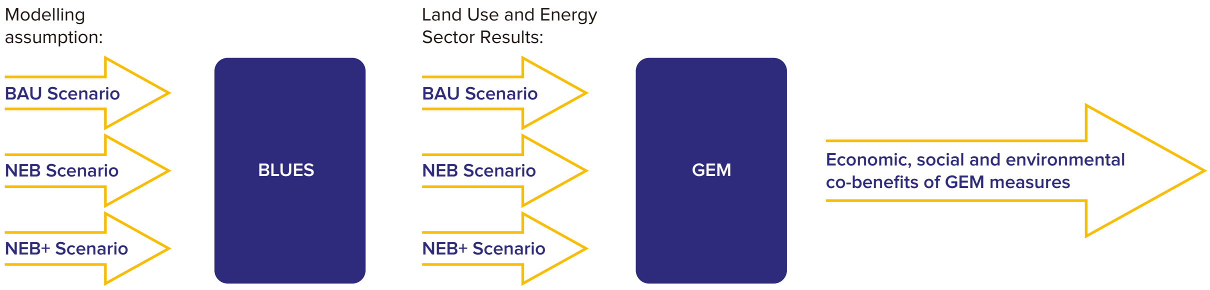
These structures are tightly coupled to reflect feedback relations, including reinforcing and balancing effects and unforeseen consequences of policies and shocks. Depending on the needs of clients and stakeholders, some structures can be replaced with alternative representations using soft (off-line) or hard couplings. Examples of this are possible linkages to otherwise self-contained representations of the energy system, such as the BLUES model, or a Computable General Equilibrium (CGE) economic structure.

A.1.3. The Integrated Modeling "BLUES-GEM"

The methodological procedure used in this study was based on a review of existing modeling exercises in Brazil as well as sectoral studies. It aims to identify opportunities and measures for a new approach to economic growth for Brazil. The integrated modeling "BLUES-GEM" was designed to demonstrate the potential economic, social, and environmental benefits of such measures by quantifying gains. The BLUES model was run to quantify effects in terms of energy use, GHG emissions, and land use. These results, in turn, feed the GEM, which, based on such information, estimates co-benefits in terms of productivity gains, economic growth, jobs, GHG emissions, and environmental pressures. Figure A3 shows these interactions.

Figure A3

Integrated modeling "BLUES-GEM"



Source: prepared by the authors.

This modeling exercise helps to fill a gap in empirical work by highlighting and helping to build evidence on the socio-economic benefits of low-carbon pathways, including spatial and temporal trade-offs in the transition to a new economy.

The list of the sectors included in the "BLUES-GEM" model is:

- Population and food demand
- Health care: primarily cost of health (from emissions, fires)
- Infrastructure: roads, power generation
- Economic value added (GDP): agriculture, industry, and services
  - Productivity based on energy bills, power cuts, roads (connectivity), emissions (air quality), land productivity (for agriculture)
- Government accounts
- Households accounts

- Employment
- Land cover: agriculture (selected crops), settlement, forest, fallow land
- Agriculture production (selected crops), losses (also based on infrastructure), and livestock
- Water demand and supply: wastewater treatment
- Energy demand and supply (from BLUES)
- Electricity supply (from BLUES)
- Air emissions and carbon sequestration

Three scenarios with increasing degrees of penetration of measures for a new economy have been created using GEM-Brazil:

1. **Business-as-usual (BAU):** This scenario reflects the continuation of current business-as-usual trends. It includes a slowly declining GDP growth rate, growing GHG emissions, and slightly increasing unemployment. In this scenario, GHG emissions reductions would be 19% in 2025 related to 2005 levels, compared with the Brazilian Nationally Determined Contribution (NDC) target of a 37% reduction in 2005 emission levels by 2025.

2. **New Economy for Brazil (NEB):** This scenario reflects a series of low-carbon actions identified by the Alberto Luiz Coimbra Institute for Graduate Studies and Engineering Research of the Federal University of Rio de Janeiro (COPPE/UFRJ) using the BLUES model (Brazilian Land Use and Energy System). This includes hybrid vehicles, electric vehicles, gasoline vehicles, greater use of charcoal in iron and steel segments, and systems of high agricultural and pasture productivity. In addition, the NEB scenario includes some economy-wide interventions that can deliver higher economic growth while reducing emissions. For instance, enhanced energy efficiency (2% additional improvement per year), reduction in food loss (both pre- and post-harvest), and increased wastewater treatment. This scenario would lead to 48% less GHG emissions in 2025 compared with 2005 levels. The NEB scenario shows a strong economic growth due to:

    - reduction in energy bills;
    - reduced emissions and air pollution;
    - reduced water pollution;
    - increased agricultural production resulting from less food losses; and
    - greater investment, access to health and literacy because of the higher levels of GDP.

3. **NEB+:** This scenario is similar to NEB, but with NEB+ half of the land currently used could be “compensated for” through (1) reducing food loss while still maintaining the same level of agricultural production as in the BAU scenario, (2) high-productivity crops or livestock as described in Section 5 of this document, and (3) increases in forest restoration and reductions in illegal deforestation. This scenario would lead to 42% less GHG emissions in 2025 compared with 2005 levels. Due to greater economic activity in this scenario, there is more demand for energy, which in turn increases GHG emissions in the short term to the same levels as the NEB scenario. However, it would still lead to a greater reduction in emissions compared to the current International Climate Regime in the Paris Agreement. Additionally, over time, this impact decreases. From 2031, the NEB+ scenario becomes similar to the NEB scenario in terms of GHG emission reductions, and from 2035 it exceeds the potential of GHG emission reduction.

A.2 Supplementary Results

A.2.1 Brazilian Land Use and Energy Systems Model (BLUES)

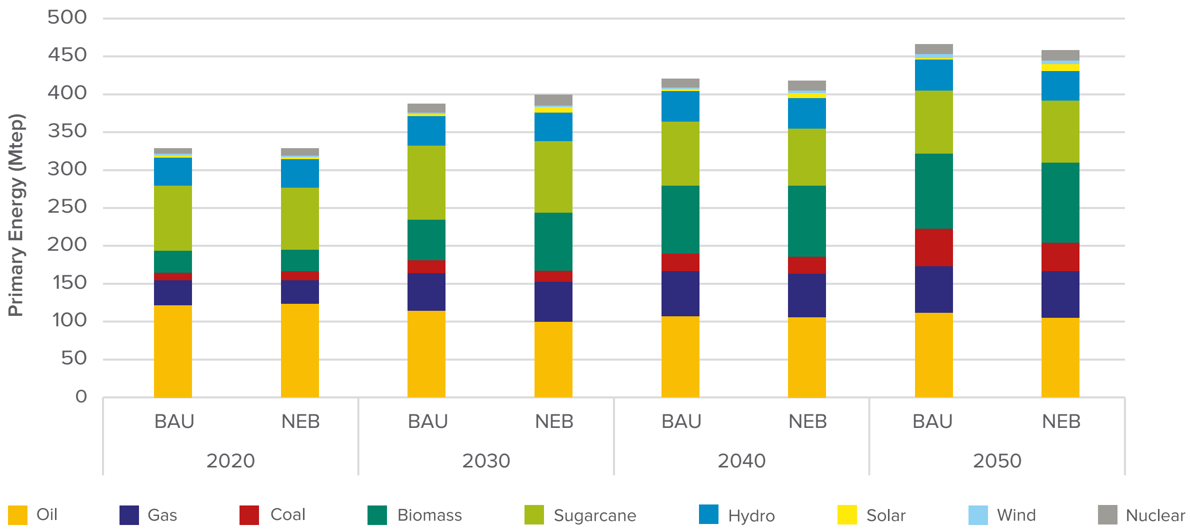
The BLUES model simulated the BAU and NEB scenarios. It provided, among other results, the least cost expansion of energy and land use systems. Driven by a projected increase in the demand for energy services, the model optimizes the whole energy production chain by 2050 (from resources and primary energy, energy conversion, and transportation technologies to specific end-uses). Land use is driven by exogenous demand for food and endogenous land requirements for producing biofuels. Here, a basic set of results is presented.

Figure A4 show that fossil fuels could remain relevant up to 2050, albeit with a slightly lower consumption of crude oil and a higher consumption of natural gas and coal. Reduction in crude oil consumption results from switching fuels in the transportation sector. Alternative fuels, such as electricity and biofuels, account for some consumption. The increase in coal consumption is driven by electricity generation, which the model regards as a low-cost option in the absence of policies to internalize its external costs. Natural gas, in turn, results from a higher supply of natural gas from pre-salt oil production and is mostly directed to energy consumption in industry and buildings. Biomass consumption increases considerably and provides feedstock for conventional and advanced biofuels.

The NEB scenario leads to a slightly lower overall primary energy consumption. However, it should be noted that the NEB scenario shows a lower consumption of fossil fuels and a higher penetration of solar energy.

Figure A4

Primary energy in BAU and NEB scenarios – BLUES

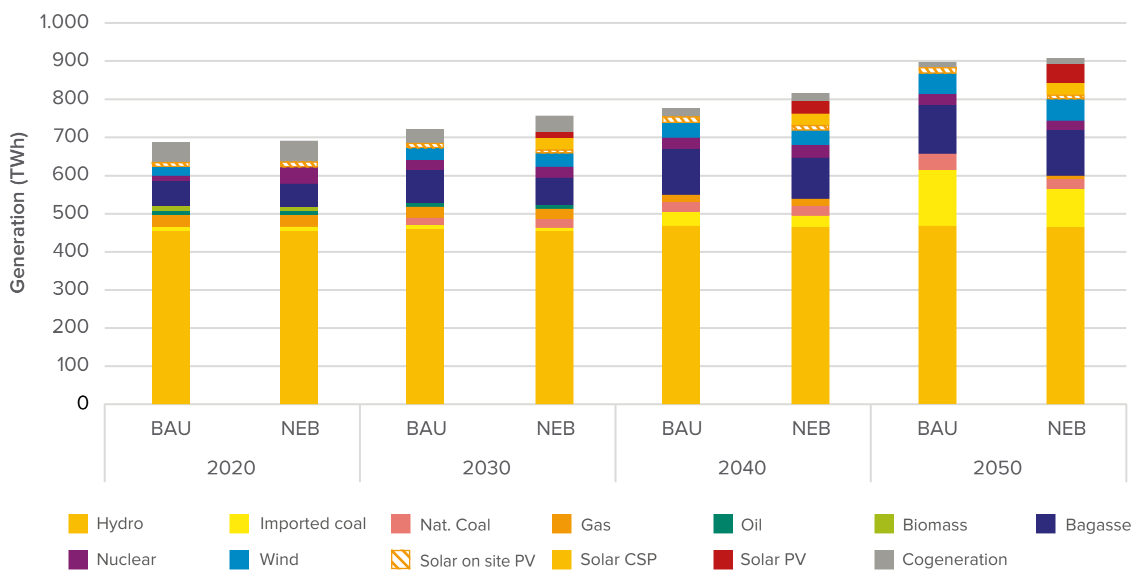


Source: prepared by the authors.

Electricity generation projected by the BLUES model (Figure A5) shows a more diverse mix as power generation increases throughout the analysis period. Nevertheless, hydropower still remains relevant in 2050, when it accounts for roughly half of all electricity generated in Brazil. The penetration of coal-fired power plants, as already mentioned, is a result of its low cost if externalities are not considered. However, the comparison between the BAU and NEB scenarios shows that policies stimulating solar power generation displace additional coal-based energy generation. The results also show that such fuel switching has a low impact on electricity prices.

Figure A5

Electricity generation by source in BAU and NEB scenarios – BLUES

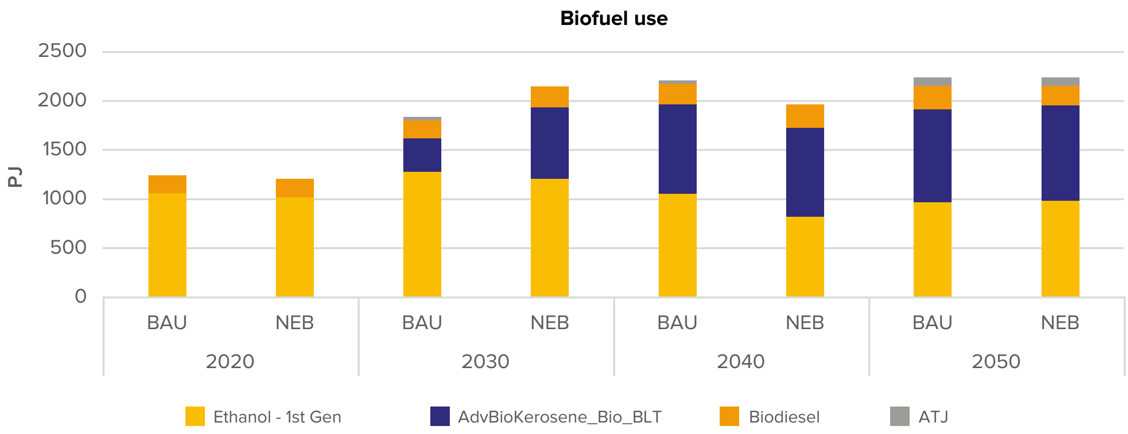


Source: prepared by the authors.

The use of biomass feedstock for energy production (Figure A6) becomes more diversified by including advanced biofuels, such as biojet fuel, due to biomass-to-liquid (BTL) or alcohol-to-jet (ATJ) production routes. Advanced biofuels are an opportunity for seizing market share in demand-inelastic markets and for avoiding competition with light electric vehicles.

Figure A6

Biofuel production in BAU and NEB scenarios – BLUES



Source: prepared by the authors.

The results show two scenarios for the industrial sector. First, the increase in the supply of associated natural gas from pre-salt production fields leads to a higher use of this fuel by the industrial sector. Secondly, the increase in energy costs stimulates energy efficiency measures, which are especially adopted in the cement and chemicals sector and to a lower extent in the steel industry and other sectors. In the NEB scenario particularly there is a larger use of charcoal in steel production.

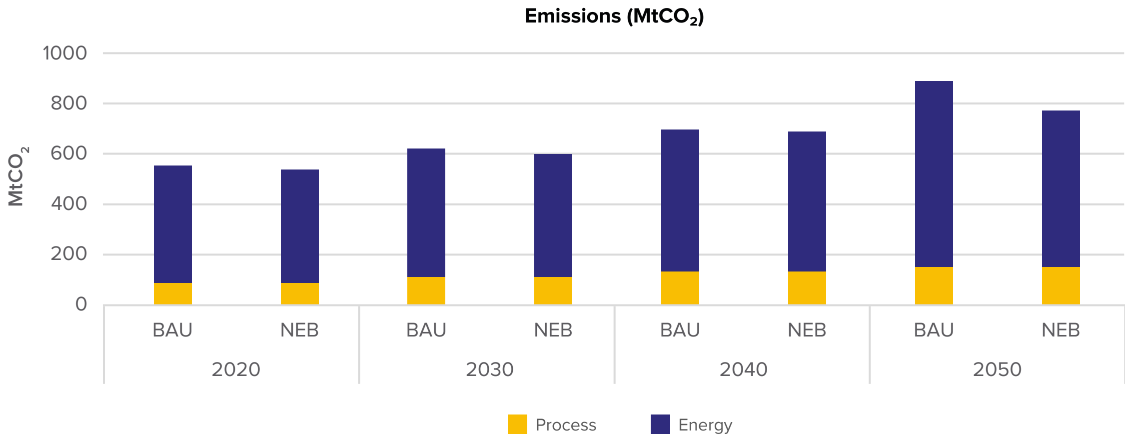
The consumption of natural gas also increases in buildings, as the model projects the expansion of the network to reach more cities. There is energy efficiency in lighting and other appliances in the scenarios for the buildings sector, even more so in the NEB scenario. The major shift in buildings, however, is their increasing role as energy producers with on-site solar photovoltaic generation.

Electrification of passenger transportation starts modestly in 2030 and reaches 9% by 2050 (with a slightly higher share in the NEB scenario). Despite this low penetration, electrification lowers total energy consumption in transportation due to the high efficiency of electric vehicles. Low energy consumption also arises from hybrid ethanol vehicles, allowing surplus ethanol to be directed to freight and production of advanced biofuels. Energy efficiency is also achieved by ethanol-fueled hydrogen trucks. This is particularly relevant because it displaces diesel consumption.

Projected emissions from energy and industrial processes in the NEB scenario are 13% lower than those of BAU by 2050 if all proposed measures are implemented (Figure A7). This is a direct result from energy efficiency and fuel switching measures simulated in the NEB scenario.

Figure A7

Emissions from energy and industrial processes in BAU and NEB scenarios – BLUES

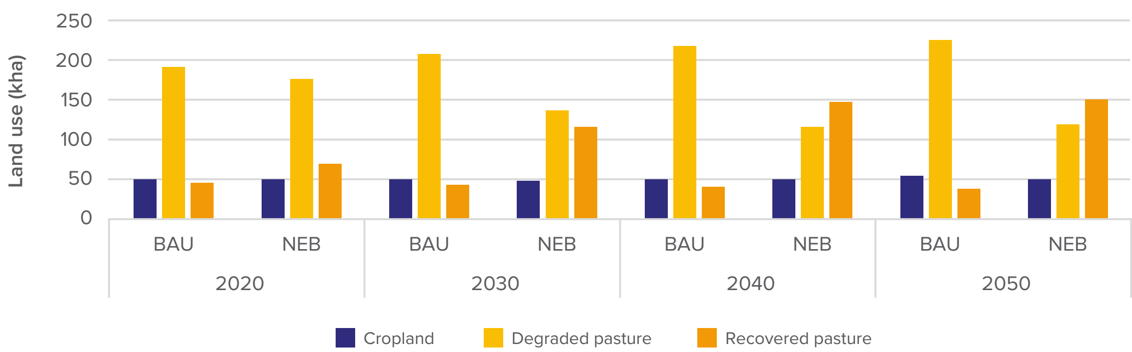


Source: prepared by the authors.

Finally, the land use measures proposed in NEB lead to a relevant conversion of degraded pasture to high-productivity pastures, as Figure A8 shows. They reduce pressures on deforestation and lower emissions by storing carbon in the soil.

Figure A8

Land use in BAU and NEB scenarios – BLUES



Source: prepared by the authors.

The BLUES model projects low rates of deforestation in the BAU and NEB scenarios. In the BAU scenario, the average annual deforestation in Brazil is 3,500 km^2 (vs. 3,300 km^2 in the NEB scenario). This is well below the lower historical annual rate recorded in the Amazon alone (4,500 km^2 in 2012). As a cost optimization method, deforestation in BLUES is driven by (i) the search for high-productivity and low-cost land, or (ii) the need to expand productive lands by converting natural land cover (forest or savannah) to address food and energy demands. Other issues that drive deforestation in Brazil, such as land tenure, are not modeled in BLUES. The low deforestation results found in this simulation show that projected demand for food and energy does not create relevant pressure for converting natural landscapes to increase cultivable lands. On the contrary, deforestation is driven by the conversion of sweet spots of high-productivity and low-cost land, which are extremely limited.

Although deforestation in the NEB scenario is not significantly lower than in the BAU scenario (which is already low), the recovery of pasture increases land availability and contributes to lower emissions by absorbing carbon in the soil. The stock of carbon in the soil, provided by recovering pastures in the NEB scenario, accumulates up to 4 $GtCO_2$ by 2050.

A.2.2 The Green Economy Model for Brazil

GEM includes four key capitals (physical, human, social, and natural) interconnected by an explicit representation of feedback loops (reinforcing or balancing). Policies can be implemented to strengthen growth (i.e., reinforcing loops) or curb changes (e.g., by strengthening balancing loops).

In this study, GEM was used to (1) test the effectiveness of individual policies and investments (by assessing their impacts inside and across sectors and for social, economic, and environmental indicators), and (2) inform development planning (by assessing the outcomes of a simultaneous implementation of various intervention options).

The GEM-Brazil model was designed to include all key sectors relevant for the future development of Brazil. They include, among others, population, food demand and supply, land use and cover, economic activity, employment, access to health care and education, energy demand and supply (linked to the BLUES model), atmosphere emissions, water pollution, and climate trends. The model also provides an economic valuation of the following externalities: atmosphere emissions (social cost of carbon), air pollution, wastewater, waste, traffic-related impacts (e.g. accidents, noise), opportunity cost of water (from savings in the agriculture sector), and biodiversity.

The following tables show the main results of the simulation of BAU, NEB, and NEB+ scenarios with GEM.

Table A4 shows that GDP is forecasted to grow at a higher rate in the NEB and NEB+ scenarios than in the BAU scenario. The combined impacts of improved productivity (due to reduced energy consumption and costs, and air and water pollution) and higher job creation leads to a GDP growth 1% and 1.6% higher by 2025 in the NEB and NEB+ scenarios, respectively. The gain decreases in the longer term, when the new investment and policy ambitions also decrease and reach 0.7% and 0.9% by 2040 in the NEB and NEB+ scenarios, respectively. GDP, in turn, affect government and household accounts, resulting in higher government revenues and disposable income.

Table A5 shows gains in employment. Contrary to GDP growth, which is a year-on-year change, employment captures cumulative impacts over time. In this case, total employment is forecasted to be 3.1% and 6% higher by 2040 in the NEB and NEB+ scenarios, respectively. 2040 has the higher gain compared to the BAU scenario due to both direct and indirect job creation over time. It is worth noting that job creation is expected for industry and services, not for agriculture. This is due to scenario assumptions, which limit land conversion and reduce the expansion of agriculture lands as observed in the BAU scenario. Nevertheless, due to improvements in productivity, income per farmer is forecasted to increase by more than 40% by 2030 in the NEB and NEB+ scenarios.

Table A6 shows GHG emissions from land (LULUCF), agriculture, energy, industry, and waste. A significant fraction of the reduction in carbon emissions through the 2020s and part of the 2030s occurs in lands, which is related to a reduction in the expansion of agricultural lands and to reforestation efforts. Over the horizon, gains in terms of carbon emissions reduction tends to be increasingly associated with the energy sector both due to a bigger shift towards renewable energy sources and gains in energy efficiency. There is a marked decrease in total emissions in the NEB and NEB+ scenarios compared to that of the BAU scenario in the medium term (-28.2% by 2030), followed by a closing in the gap across scenarios (-0.8% by 2040). The latter scenario is associated firstly with reductions in land conversion and restoration efforts towards the end of the simulation period. Secondly, it is associated with the offsetting of gains in energy efficiency and energy shifts towards renewable energy compared to increased emissions from higher economic activity in the NEB and NEB+ scenarios versus the BAU scenario. It is worth noting that this difference is estimated for a given year, not for the cumulative reduction over time. The latter scenario continues to grow throughout the simulation. It indicates 20 years of net emissions savings emerging from the NEB and NEB+ scenarios compared to that of the BAU scenario. The main reason for the trends shown in Table A6 is the following:

- The policy ambition for land-related interventions is at its peak in the medium term. When reforestation goals are reached, emissions decline. This causes the largest reduction in the medium term and the smallest reduction by 2040.

- For all other sectors, the reduction is stable and more progress in reducing emissions is achieved for the energy sector over time. This is due to the longer lifetime of investments and their cumulative impact. However, these sectors also see a trend towards progress eroding as well, although less marked due to rebound effects. This happens when investments lead to a higher GDP, which in turn stimulates energy consumption and leads to more emissions.

- Finally, emissions from industry and waste increase over time following the trend of population and GDP because no interventions have targeted industrial processes and waste.

It is also worth noting that the gains in value adding and income derived from the NEB and NEB+ scenarios lead, all other factors held stable, to a partial offsetting of the reduction in emissions initially obtained, from a higher energy demand associated to an also higher economic activity. In the NEB and NEB+ scenarios, the gains in emissions reduction associated with policy exceed the rebound effects in energy demand related to higher economic activity.

Table A7 shows the total value of externalities estimated by the model and the breakdown by category. The table shows the most important gains are achieved for the costs of air and water pollution, followed by the economic value of waste savings. It is important to note the creation of a positive externality, income generation from job creation.

Table A4

Forecasted value for GDP, and total (real and nominal) and real GDP growth rate

GDP and GDP growth							
Variables	**Scenario**	**Unit**	**2020**	**2025**	**2030**	**2035**	**2040**
Real GDP (base year 2000)	BAU	bn R$ / Year	2,710	3,110	3,510	3,912	4,260
	NEB	bn R$ / Year	2,724	3,284	3,812	4,372	4,926
	NEB vs BAU	%	0,5%	5,6%	8,6%	11,7%	15,6%
	NEB+	bn R$ / Year	2,729	3,375	4,029	4,670	5,310
	NEB+ vs BAU	%	0,7%	8,5%	14,8%	19,4%	24,7%
Nominal GDP	BAU	bn R$ / Year	7,272	9,969	13,437	17,885	23,257
	NEB	bn R$ / Year	7,312	10,525	14,591	19,984	26,891
	NEB vs BAU	%	0.5%	5.6%	8.6%	11.7%	15.6%
	NEB+	bn R$ / Year	7,325	10,816	15,421	21,348	28,993
	NEB+ vs BAU	%	0.7%	8.5%	14.8%	19.4%	24.7%
Real GDP growth rate	BAU	%	3.1%	2.6%	2.4%	2.1%	1.6%
	NEB	%	3.4%	3.6%	3.0%	2.7%	2.3%
	NEB+	%	3.5%	4.2%	3.5%	2.9%	2.5%

Source: prepared by the authors.

Table A5

Forecasted value for employment, total and by sector, with percent change compared to the BAU scenario

Employment							
Variable	**Scenario**	**Unit**	**2020**	**2025**	**2030**	**2035**	**2040**
Total employment	BAU	Person / Year	92,882,008	97,063,144	100,468,968	103,697,280	107,012,592
	NEB	Person / Year	92,888,032	97,120,456	101,104,160	105,490,224	110,277,776
	NEB vs BAU	%	0.0%	0.1%	0.6%	1.7%	3.1%
	NEB+	Person / Year	92,896,848	97,608,440	102,484,520	107,764,664	113,440,208
	NEB+ vs BAU	%	0.0%	0.6%	2.0%	3.9%	6.0%
Agriculture	BAU	Person / Year	65,896,968	66,811,096	67,626,032	68,339,256	68,953,712
	NEB	Person / Year	65,883,248	66,321,844	66,657,636	67,233,872	67,728,368
	NEB vs BAU	%	0.0%	-0.7%	-1.4%	-1.6%	-1.8%
	NEB+	Person / Year	65,889,760	66,539,796	67,029,008	67,576,896	68,011,712
	NEB+ vs BAU	%	0.0%	-0.4%	-0.9%	-1.1%	-1.4%
Industry	BAU	Person / Year	12,035,197	13,926,157	15,236,651	16,433,063	17,756,656
	NEB	Person / Year	12,044,199	14,167,853	15,936,926	17,691,276	19,707,176
	NEB vs BAU	%	0.1%	1.7%	4.6%	7.7%	11.0%
	NEB+	Person / Year	12,045,240	14,286,951	16,374,208	18,525,856	20,959,202
	NEB+ vs BAU	%	0.1%	2.6%	7.5%	12.7%	18.0%
Services	BAU	Person / Year	14,949,844	16,325,893	17,606,288	18,924,960	20,302,226
	NEB	Person / Year	14,960,586	16,630,756	18,509,600	20,565,072	22,842,234
	NEB vs BAU	%	0.1%	1.9%	5.1%	8.7%	12.5%
	NEB+	Person / Year	14,961,845	16,781,696	19,081,304	21,661,908	24,469,292
	NEB+ vs BAU	%	0.1%	2.8%	8.4%	14.5%	20.5%

Table A6

Forecasted value for GHG emissions, total and by sector, with percent change compared to the BAU scenario

Emission							
Variable	**Scenario**	**Unit**	**2020**	**2025**	**2030**	**2035**	**2040**
Total annual CO_2e emissions	BAU	mil ton / Year	1,825.5	1,914.6	2,039.8	2,075.5	2,090.0
	NEB	mil ton / Year	1,634.2	1,227.3	1,366.0	1,632.2	2,084.2
	NEB vs BAU	%	-10.5%	-35.9%	-33.0%	-21.4%	-0.3%
	NEB+	mil ton / Year	1,707.7	1,378.0	1,463.9	1,622.8	2,072.5
	NEB+ vs BAU	%	-6.5%	-28.0%	-28.2%	-21.8%	-0.8%
Emissions from land	NEB vs BAU	%	-15.8%	-52.7%	-44.5%	-25.6%	13.1%
	NEB+ vs BAU	%	-9.6%	-41.0%	-39.3%	-29.5%	8.1%
Emissions from agriculture	NEB vs BAU	%	-55.7%	-45.5%	-47.7%	-45.9%	-39.7%
	NEB+ vs BAU	%	-55.3%	-38.4%	-34.5%	-32.1%	-24.2%
Emissions from energy	NEB vs BAU	%	-1.4%	-13.0%	-18.7%	-19.3%	-24.8%
	NEB+ vs BAU	%	-1.3%	-10.6%	-14.0%	-13.8%	-19.0%
Emissions from Industry and waste	NEB vs BAU	%	0.1%	3.1%	6.9%	10.2%	14.3%
	NEB+ vs BAU	%	0.1%	3.6%	8.7%	13.6%	19.1%
CO_2e emissions per capita	NEB vs BAU	%	-10.5%	-35.9%	-33.0%	-21.2%	0.1%
	NEB+ vs BAU	%	-6.5%	-28.0%	-28.1%	-21.5%	-0.2%

Table A7

Forecasted value of externalities, total and disaggregation, with percent change compared to the BAU scenario

Externality							
Variable	**Scenario**	**Unit**	**2020**	**2025**	**2030**	**2035**	**2040**
Total value of externalities	BAU	bn R$ / Year	374,618.1	390,036.6	405,679.6	421,565.8	437,756.4
	NEB	bn R$ / Year	374,590.7	389,862.6	405,215.7	420,634.5	436,118.5
	NEB vs BAU	%	0.0%	0.0%	-0.1%	-0.2%	-0.4%
	NEB+	bn R$ / Year	374,599.9	389,840.4	405,008.6	420,075.6	435,134.3
	NEB+ vs BAU	%	0.0%	-0.1%	-0.2%	-0.4%	-0.6%
Social cost of carbon	NEB vs BAU	%	-10.5%	-35.9%	-33.0%	-21.4%	-0.3%
	NEB+ vs BAU	%	-6.5%	-28.0%	-28.2%	-21.8%	-0.8%
Cost of air pollution	NEB vs BAU	%	4.0%	0.7%	-14.9%	-15.0%	-35.8%
	NEB+ vs BAU	%	4.0%	0.7%	-14.9%	-15.0%	-35.6%
Cost of water pollution	NEB vs BAU	%	-0.2%	-3.0%	-7.4%	-10.1%	-11.2%
	NEB+ vs BAU	%	-0.2%	-3.0%	-7.5%	-10.3%	-11.5%
Cost of waste	NEB vs BAU	%	-0.8%	-4.6%	-8.5%	-8.6%	-8.8%
	NEB+ vs BAU	%	-0.8%	-4.6%	-8.6%	-8.8%	-9.0%
Traffic related externalities	NEB vs BAU	%	0.0%	0.0%	-0.1%	-0.2%	-0.4%
	NEB+ vs BAU	%	0.0%	0.0%	-0.1%	-0.3%	-0.6%
Opportunity cost of water (agriculture)	NEB vs BAU	%	3.7%	3.6%	-6.2%	-7.7%	-24.6%
	NEB+ vs BAU	%	3.7%	3.6%	-6.2%	-7.7%	-24.4%
Labor income and discretionary spending	NEB vs BAU	%	0.0%	0.1%	0.6%	1.7%	3.1%
	NEB+ vs BAU	%	0.0%	0.6%	2.0%	3.9%	6.0%

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